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XXV (1939)

PART I: BOTANY AND FORESTRY

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VOLUME XXV (1939)

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PAPERS OF THE MICHIGAN ACADEMY OF SCIENCE ARTS AND LETTERS

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VOLUME XXV (1939)
PART I: BOTANY AND FORESTRY

"Pusilla res mundus est nisi in illo
quod quaerat omnis mundus habeat."
— SENECA, *Naturales Quaestiones*

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CONTENTS

BOTANY

PAGE

Sumatran Palms. I. Calamoxleya, a Subgenus of Calamus Typified by *C. leiospathus*, a New Species Related to *C. Oxleyanus*. Harley Harris Bartlett 3

Varicosporium Elodeae Kegel, an Uncommon Soil Fungus. Ernst A. Bessey 15

Anatomy of *Urginea maritima* (L.) Baker. Dorothy Chapman Carpenter 19

Some Vegetational Aspects of Beaver Island, Lake Michigan. Henry Townsend Darlington 31

Additions to the Flora of Michigan. II. Clarence R. Hanes ... 39

Records for the Gramineae of the Douglas Lake Region, Michigan. LeRoy Hatfield Harvey 43

Lichens of Northern Michigan. Joyce Hedrick 47

Notes on Plant Ecology of Northern Ontario. Leslie A. Kenoyer 67

Plant Associations in Barry, Calhoun, and Branch Counties, Michigan, as Interpreted from the Original Survey. Leslie A. Kenoyer 75

Cordyceps Species from Michigan. Edwin B. Mains 79

Nuclei in Actinomyces. Earl H. Newcomer and Glenn KenKnight 85

Desmids of Isle Royale, Michigan. The Genera Staurastrum, Micrasterias, Xanthidium, and Euastrum, with a Note on Spinoclosterium. Gerald W. Prescott 89

Notes on Bryophytes of Central Michigan. Irma Schnooberger 101

Studies in the Genus Agaricus. Alexander H. Smith 107

Morphological Studies on the Seed of Snapdragon (*Antirrhinum majus* L.). Edward F. Woodcock 139

FORESTRY

Some Resupinate Polypores from the Region of the Great Lakes. XI. Dow V. Baxter 145

Frost Heaving of Forest Planting Stock at the Kellogg Reforestation Tract, near Battle Creek, Michigan. Merrill E. Deters 171

Some Notes on the Preparation of *Cyathus stercoreus* as a Test Organism for the Rapid Determination of Decay Resistance in Treated Timbers. Frederick H. Vogel 179

ILLUSTRATIONS

PLATES

BOTANY

FACING PAGE

BARTLETT: Pls. I–IV. Details of leaf, inflorescence, flowers, fruit, and seed of *Calamus* (*Calamoxleya*) *leiospathus* 14

CARPENTER: Pls. I–II. Habit sketches and other details of *Urginea maritima* (L.) Baker 30

DARLINGTON: Pls. I–III. Vegetation of Beaver Island, Lake Michigan 38

MAINS: Pls. I–III. *Cordyceps unilateralis*, *C. gracilis*, and *C. paludosa* 84

PRESCOTT: Pls. I–IV. Desmids of Isle Royale 100

SMITH: Pls. I–X. Species of Agaricus 138

WOODCOCK: Pls. I–III. Seed of *Antirrhinum majus* L. 142

FORESTRY

BAXTER:

Pls. I–VII, XII. Species of resupinate polypores 170

Pls. VIII–XI. Views of a house badly damaged by *Poria incrassata* 170

FIGURES IN THE TEXT

BOTANY

PAGE

BESSEY: Figs. 1–2. Spores and modes of branching of *Varicosporium Elodeae* 16

DARLINGTON: Fig. 1. Map of Beaver Islands, Lake Michigan (*after*) 32

KENOYER: Fig. 1. Plant associations of Barry, Calhoun, and Branch counties, Michigan 76

SMITH: Figs. 1–4. Spores of American species of Agaricus 110, 123, 129, 134

BOTANY

SUMATRAN PALMS. I

CALAMOXLEYA, A SUBGENUS OF CALAMUS TYPIFIED BY *C. LEIOSPATHUS*, A NEW SPECIES RELATED TO *C. OXLEYANUS* *

HARLEY HARRIS BARTLETT

FROM a practical standpoint so immense and highly diversified a genus as Calamus might well be divided if it were possible to segregate clearly natural genera of more than a single or a few species. The immediately segregable elements, however, if removed, would hardly leave the residual genus less cumbersome. Consequently it is better to attempt to define groups tentatively, as subgenera within Calamus, which, if they stand the test of time as distinct and logical assemblages, may eventually, perhaps, be considered worthy of generic status.

Before Calamus in the broad sense can be reviewed much more thoroughly than it was by Beccari, intensive collecting must be done through almost the entire range of the genus. During the last few years the careful collecting of a native Sumatran, Rahmat Si Boeeja, has brought about the accumulation, in the University of Michigan Herbarium, of an unusually adequate suite of Sumatran palms, including Calami and other rotans, from the Batak lands and the East Coast.

At the present time many undoubtedly valid palm species are known from material so defective that it is impossible to place them with their natural associates on the basis of the characteristics that must be used for establishing either subgenera or genera. The herbarium specimens are so insufficient, sometimes only male, sometimes only female, sometimes lacking leaves or sheaths, or other essential parts, that certain species have to be placed by guess as

* Papers from the Department of Botany and the Botanical Gardens of the University of Michigan, No. 691.

Calami even in the present broadly inclusive sense. One obvious advantage of first proposing as subgenera subdivisions of the too-inclusive genus is, of course, that no established binomials need be disturbed until reasonable certainty is arrived at regarding the position of most of the species.

In this article the writer proposes Calamus subgenus Calamoxleya to include climbing palms differing from the great majority of Calami in having strongly cirrhiferous leaves, nonflagelliferous leaf sheaths, and nonflagelliform inflorescences which, however, arise from and are adnate to the leaf sheaths. In this assemblage of characteristics subgenus Calamoxleya resembles Daemonorops. That its retention in Calamus *sens. lat.* is not irrational is immediately indicated by the tubular persistent spathes and by the subuncinate spines of the inflorescence, the latter providing a point of slight resemblance to those Calami which show all gradations between a strongly clawed sheath flagellum and an inflorescence practically always flagelliform in its terminal part. Subgenus Calamoxleya has as the terminal portion of the inflorescence a vestigial sterile structure (*caudicula*), which is short and remarkable for its subinflated sheaths, not at all for any resemblance to the typical clawed flagellum of most Calami, for it has no united "hands" of retrorse claws. The sparse thorns are solitary and, if only vaguely uncinate, at least not quite straight.

A difference between subgenus Calamoxleya and the vast majority of Calami and Daemonoropes is that the leaves of mature, flowering specimens lack or only vaguely suggest the usually pronounced gibbosity of the leaf sheath below the insertion of the petiole. There are a few aberrant species in Daemonorops that have nongibbous sheaths, but, so far as I know, there exist no climbing Calami with nongibbous sheaths, with the exception of *Calamus Oxleyanus* Teysm. & Binnend. ex Miquel[1] and the new *Calamus leiospathus*, which is to be considered the type species of subgenus Calamoxleya. The nongibbous leaf sheath is found in genera allied to Calamus, such as Plectocomia, Plectocomiopsis, and Myrialepis. It is to be noted that *C. Oxleyanus* is described as erect when young and as climbing in age, and that those species of Daemonorops with nongibbous sheaths are also described as nonscandent.

[1] Miquel, F. A. Guil., *De palmis Archipelagi Indici observationes novae.* Amstelodami: apud C. G. Van der Post, 1868.

In general, the Calami and the Daemonoropes show a very interesting negative correlation with regard to flagellum and cirrhus. If the leaves terminate in a clawed cirrhus, the inflorescence has no flagelliform, clawed, sterile appendage, and the sheaths are not flagelliferous. (In Calamus the flagella are, morphologically, sterile inflorescences, and all degrees of sterilization are to be found. Both flagella and inflorescences arise from and are adnate above to the outside of the leaf sheath.) On the contrary, if sheath flagella and the morphologically equivalent flagelliferous inflorescences are found, the clawed cirrhus is usually missing or vestigial. Only in exceptional species is it well developed. In *C. Oxleyanus* the similarity in vegetative structures to Daemonorops is so great that one might easily put this species in the latter genus (as Martius, in fact, did) if the inflorescence were unknown. Inclining in vegetative morphology to Daemonorops, but in more fundamental characteristics to Calamus, the new subgenus Calamoxleya superficially resembles Plectocomiopsis and certain other genera of that alliance in its nongibbous sheaths. The latter genera, however, do not have the inflorescence adnate to the outside of, and arising from, the leaf sheath. What has only been inferred in the past is now known by the argument of analogy with the obviously very closely related new species *C. leiospathus*, namely, that the inflorescence is adnate to the leaf sheath in *C. Oxleyanus*, and that the species is therefore actually closer to Calamus than to genera with axillary or terminal inflorescences. Such evidence, previously only assumed (perhaps because the species is cultivated at Buitenzorg, where it has flowered and where herbarium specimens have been made with no note of the inflorescence being borne otherwise than is usual in Calamus), is now at hand in *C. leiospathus* from Sumatra. It is curious that descriptions have not been clear respecting this point, for Griffith,[2] Miquel (*loc. cit.*), and Beccari,[3] making no statement at all, have left the reader to assume what now proves to be the truth. Miquel's plate is entirely ambiguous, not showing the origin of the inflorescence except in the

[2] Griffith, Wm., *Palms of British East India.* Calcutta: printed by Charles A. Serrao, 1850. This important folio volume is a part of the "Posthumous Papers bequeathed to the Honorable the East India Company and printed by Order of the Government of Bengal."

[3] Beccari, Odoardo, "Asiatic Palms — Lepidocaryeae, Part I. The Species of Calamus," *Ann. Roy. Bot. Gard. Calcutta* (Calcutta: Bengal Secretariat Press, 1908), 11 : 113, 114, 450–453; pl. 203.

habit sketch, where, placed by the artist in an impossible situation, the spadix appears to arise from the petiole, not from the sheath.

The characteristic chiefly relied upon for the separation of the new Sumatran *C. leiospathus* from the original *C. Oxleyanus* of Bangka, collected by Teysmann and described by Miquel, is indicated in the name. In the so-called pistillate (actually monoecious) plants the difference between smooth or almost smooth and very thorny spathes appears to be sufficient for a clear separation, but nevertheless of too minor a nature to allow us to believe that in the more important characteristics pertaining to subgenera or genera there can be lack of coincidence between the two species. In Beccari's description there are indications of numerous more obscure differences, which cannot be relied upon because of the distinct possibility that *C. Oxleyanus*, as defined by him, includes more than one species. The specimens studied by him were from Malacca, Johore, Singapore, and the Buitenzorg Garden, the latter presumably grown from Teysmann's seeds collected in Bangka. Beccari [4] himself named one element of the possible mixture *Calamus diffusus*, but later reduced it to synonymy. The first specimen ever reported that belonged to the subgenus was found by Griffith's collector, E. Fernandez, in Malacca, about 1844, but because it was sterile Griffith referred to it in his great work on the palms (*op. cit.*, pp. 95–96) only by the Malay name, *rotang pajare*. He had sent it to Martius,[5] however, who rated it as a distinct species the affinity of which could not be made out because of the deficiency of the material, but who named it (presumably in 1848 or 1849) *Daemonorops fasciculatus*. Because of the prior *Calamus fasciculatus* Roxb., Wendland [6] could not recog-

[4] Beccari, Odoardo, "Systematic Enumeration of the Species of Calamus and Daemonorops, with Diagnoses of New Ones," *Records Bot. Surv. India*, 2: 197–230. 1902. The name *C. diffusus* Becc. occurs without description on page 206, with locality Singapore. The later monograph (footnote 3) indicates that this name was applied by Beccari in Hooker's *Flora of British India*, VI: 447, 1894, to a mixture of two presumably unrelated plants collected by Lobb at Singapore, of which the male spadix was the part that Beccari later referred to *C. Oxleyanus*. The accompanying foliage had equidistant leaflets, with the costa spinulose below, and may not have belonged with the inflorescence.

[5] Martius, Carol. Fried. Ph., *Historia naturalis palmarum*. Lipsiae, T. O. Weigel. The description of *Daemonorops fasciculatus* occurs among the last sheets published (III: 330) and, therefore, probably dates from 1849, whereas Roxburgh's prior *C. fasciculatus* dates from 1832.

[6] Wendland, H., "Index général des noms et synonymes des espèces connues," *in* Oswald de Kerchove de Denterghem, *Les Palmiers*. Paris, 1878.

nize this name when he transferred the plant to Calamus, so he renamed the species *Calamus Fernandezii*. Needless to say, only the study of fertile material from the type locality, matching the type, would justify a botanist in taking up the latter name, based as it was upon sterile material (complete leaves, with sheaths and cirrhi). It is important to note that Martius described it as "*in vaginae ore longe obliqua infraque petiolum gibbosa.*" In the material of the new Sumatran *C. leiospathus* it requires some effort of the imagination to detect a gibba on part of the sheaths, and others certainly have no suggestion of one. The gibba is too indistinct at best to be equated with the well-developed structure usually found in Calamus.

In view of the facts that the existing materials referred to *C. Oxleyanus* are fragmentary, and perhaps not all conspecific, and that the descriptions are in several important respects too vague, I have had to rely for immediate separation of *C. leiospathus* upon one dependable difference, which, although clearly indicated in the original plate and description of the older species, is not sufficiently supported by other certain differences to make one confident that it is of more than varietal significance. Other contrasting characteristics will doubtless be found, however, when it becomes possible to draw up a comparable description of *C. Oxleyanus*. The Sumatran plant is justifiably proposed as a distinct species from *C. Oxleyanus*, of which the cultivated type was grown from Bangka seeds, because rare and local palms seldom have wide ranges and because it seems absurd to typify the new subgenus Calamoxleya (which will doubtless in time be treated as a genus) by fragmentary material when there are well-nigh perfect and complete specimens available (every important part except the petiole) of the somewhat different but clearly related Sumatran plant.

The plates illustrating the descriptions that follow are by Miss Olivia Embrey.

Calamus, subgen. **Calamoxleya,** subgen. nov. — Frondes valde cirrhiferi. Inflorescentiae vaginis frondium extus adnatae, elongatae, sed non in flagella longa uncifera transeuntes. Flagella sterilia inflorescentiis aequivalentia omnino desunt. Spathae et spathellae tubulosae vel infundibuliformes, persistentes. Involucrum florum femineorum duplex, inferius depresse cupuliforme, ad marginem cicatricem vel cicatrices floris singuli masculi vel florum trium

masculorum ferens, superius vel annuliforme, varie lobatum, vel triangulum vel linguiforme (interdum apice bipartitum) vel fere obsoletum. Endosperma alveolatum, album, homogeneum. Embryo et fovea rhaphialis exacte opposita. Species duae: typica *C. leiospathus*, sp. nov. (vide infra), altera *C. Oxleyanus* Teysm. & Binnend. ex Miquel, *De palmis Archipelagi Indici observationes novae*, pp. 17–18, tabb. A et B. 1868.

Calamus (**Calamoxleya**) **leiospathus,** sp. nov. — Caulis verisimiliter scandens, vaginatus 2 2.5 cm. crassus. Vaginae (v. Tab. I, Fig. 1) colore ferrugineae vel cinnamomeae, horride spinosae, sed infra petioli insertionem in area angusta ex petioli dorso producta laeves, espinosae, omnino vel paene ebullatae, ore longe obliquae, sine ochrea. Spinae longitudine valde variantes, vel breves vel usque ad 4 cm. longae, ad basin cum vaginis concolores, sursum lucide griseae, omnes subulatae, laminares, flexiles, inordinatae vel obscure seriatae. Petiolus in speciminibus omnibus deest. Frondis pars foliolifera ca. 2.25 m. longa, in cirrho robusto uncifero (v. Tab. I, Fig. 3) terminali 80–100 cm. longo desinens. Foliola (infimo et 2 vel 3 supremis exceptis) in gregibus foliolorum 4–10 propinquorum (intervallatis secus idem latus 10–35 cm. distantibus) alternate vel subopposite disposita. Foliolum infimum solitarium ca. 160 mm. longum, 11 mm. latum. Grex inferior 3-foliolatus, foliolis inter se ca. 9 cm. distantibus, ca. 250 mm. longis, 16 mm. latis; medius ca. 7-foliolatus foliolis 250–300 mm. longis, 17–18 mm. latis, inter se ca. 12 mm. distantibus; supremus ca. 5-foliolatus, foliolis ca. 220 mm. longis, 14–15 mm. latis, inter se ca. 24 mm. distantibus, a 2 vel 3 foliolis solitariis minoribus longe distantibus secutus. Foliola omnia acuminata apice attenuata et in spinula ca. 4 mm. longa desinentia, spinulis prope folioli apicem marginalibus 2–4 mm. longis, propinquis, plerumque binis, castaneis, deorsum sparsioribus, brevioribus ad folioli marginem appressis apice castaneis basi albidis et ex insertione albida cartilaginea orientibus; venis pagina inferiore omnibus laevibus, pagina superiore 3 ex eis spinulosis, vena media sparse, spinulis distantibus, ca. 3 mm. longis, 2 venis lateralibus densius, spinulis ca. 3.5 mm. longis (v. Tab. I, Fig. 2). Rhachis parte inferiore (prope petioli apicem) subtus convexus spinas duras subflavidas triseriatas ferens, eas in serie mediana solitarias unciformes, eas in seriebus 2 sublateralibus longitudine variabiles rectiusculas paululum deflexas vel paene subunciformes, supra laevis espinosus

subconvexus; *parte media* subtus convexus spinas omnes unciformes ferens, eas seriei medianae singulas vel binas, eas laterales singulas, supra angustissime applanatus laevis pro lateribus obliquis atque foliorum insertione; *parte superiore* (prope foliola superiora) subtus angulatus unguiculatus spinis medianis binis vel ternis vel quaternis basi flavidis apice atris, spinis paucis lateralibus solitariis debilioribus quam eis aggregatis. Cirrhus 80–100 cm. longus modice robustus unguiculatus spinis medianis plerumque ternis vel quaternis, basi turgidis flavidis sursum gracilibus, fuscis. Spadix monoecius (ut dicitur "femineus") ex folii vagina oriens ca. 1 m. longus; partibus inter spathas nudis plus minusve armatis, spinis solitariis vel binis vel ternis, lateraliter compositis, retrorsis vel unciformibus, basi percurrentibus, tumidis, flavidis; ferens ramos primarios ca. 5 singulatim ex spathae ore obliquo paulo infra apicem haud ex basi orientes; desinens in caudicula brevi spathas 2 vacuas subinflatas ferente (v. Tab. II, Figg. 5–6) rhachi inter spathas caudiculae spinis 2 vel 3 solitariis rectiusculis vel retrorsis praedita, spatha suprema terminali. Spathae primariae (v. Tab. II, Fig. 4) tubulosae, 10–18 cm. longae ore longe obliquae sursum carinatae, apice acutae vel obtusiusculae, alte angulatae minute furfuraceae, aut plerumque inermes aut interdum parcissime armatae, spinis brevibus retrorsis, basi flavidis, apice fuscis. Spadicis monoecii vel "feminei" rami ca. 30 cm. longi, spiculas ca. 12 distichas 4–13 cm. longas ferentes ex oribus spatharum secondariarum; spathis secondariis primariis similibus, inermibus, ad apicem versus paulum expansis, ore longe obliquis. Spiculae ex ore spatharum haud ex basi orientes; axillis molliter parenchymatosis verisimiliter nectariferis; spathellis latere vacuo ad rhachin appressis, latere florifero valde producto expansis obtuse apiculatis. Involucrophorum cartilagineum, depresse cupuliforme una sola puncta in apiculum obtusissimum vix obvium productum. Involucrum cartilagineum duplex, membro inferiore (involucro proprio) cupuliformi extus ad marginem incrassatum inter apiculos duos obtusissimos ferente areolam sublunatam includentem floris masculi (ut dicitur "sterilis") cicatricem; membro superiore in spicae parte ultima plerumque fere nullo, in parte media asymmetrice annuliformi vel triangulo, in spicae parte proxima valde conspicuo vel annuliformi vel triangulo vel linguiformi ad involucri proprii marginem attingente et latitudine cicatricem floris feminei vel "fertilis" aequante (v. Tab. III, Fig. 7). Perianthium basi pedicelliforme (v. Tab. III, Fig. 11a)

segmentis exterioribus incrassatis tertia vel dimidia parte sursum plerumque duplo vel triplo dilaceratis, ca. 3 mm. longis, $2\frac{1}{2}$ mm. latis, intus laevibus, extus solum aetate versus apicem 10- vel 12-venosis; segmentis interioribus haud venosis, quarta vel tertia parte connatis, 3 mm. longis, $1\frac{3}{4}$ mm. latis, margine integris, apice acutis. Staminodia basi connata cupulam 6-apiculatam formantia (v. Tab. III, Fig. 11b) apicibus quam sepalis brevioribus, angustatis, truncatis; sinibus latis nec profundis, semiellipticis. Fructus immaturi valide mucronati, lepidibus circumundique 12-seriatis, stramineis, nitidis, latioribus quam longioribus, obscurissime canaliculatis, margine brunneo excepto concoloribus. Flores ex involucri latere masculi (nec, ut dicitur "steriles") ante anthesin 5 mm. longi anguste cylindrici; calyce distincte nervoso vix alabastri mediam attingente, apice obtuse leviterque tridentato, deinde (flore aperto) profundius tripartito et in cupulam brevem depressam expanso (v. Tab. III, Fig. 8); petalis anguste oblongis, non nervosis, apice acutis, deinde usque ad basin separatis; staminibus 6 paene separatis fertilibus; antheris mediatenus versatilibus, 2.5 mm. longis (v. Tab. III, Fig. 9), normaliter dehiscentibus polline bene formato (v. Tab. III, Fig. 10) praeditis; filamentis atrocoloratis mediae antherae adfixis, infra basin antherarum $1\frac{1}{2}$ mm. longis. (Descriptio hucusque ex specimine "femineo" (meliuscule monoecio) typico *Rahmat 6172:* incipit descriptio fructuum ex *Rahmat 7616* et inflorescentiae masculae ex specimine masculo typico *Rahmat 7340.*) Fructus maturi vel paene maturi (v. Tab. III, Fig. 12) 11–12 mm. longi, 11–14 mm. lati; stipite 2 mm. longo, mucrone 2 mm. longo; lepidibus 12-seriatis, stramineis, margine cinnamomeis, longitudinaliter vix sulcatis; semine subgloboso, 10–13 mm. diam.; endocarpio crasso atrorubro, molli, in siccitate irregulariter foveolato; endospermio hemicelluloso albo homogeneo late turbinato, latiore (8–9 mm.) quam altiore (6–7 mm.), ab intrusione endocarpii grosse foveolato (v. Tab. III, Figg. 13 a–c). Embryo et raphe exacte opposita, polaria (v. Tab. III, Fig. 14). Spadix masculus longitudine varians usque ad 170 cm., in caudicula perbrevi sterili desinens (v. Tab. IV, Fig. 16) ramos primarios, secondarios et tertiarios (i.e. spiculas) ferens; ramis secondariis ex oribus spatharum orientibus, longioribus eorum ca. 15 cm. longis, spiculas 8–15 laterales 2–8 cm. longas et spicam terminalem unicam quam lateralem propinquam duplo longiorem ferentibus. Spathae primariae ore longe obliquae, omnino inermes vel 1–2 spinis prope

insertionem praeditae, inter se amplectentes, infima ca. 29 cm. longa, semicylindrica, aliae sequentes omnes inermes (v. Tab. IV, Fig. 16) subinfundibuliformes, intermediae ca. 15 cm. longae, superiores ca. 4 cm. longae. Spathae secondariae oribus magis patentes, nec sese attingentes, mediocres plerumque ca. 4 cm. longae, basi diam. 3 mm., sursum expansae, apice obliquo 7–8 mm. diam., papyraceae, sub lente venosae; tertiariae (spiculas subtendentes) similes sed parviores, saepe solum 6–7 mm. longae, basi $1\frac{1}{2}$–2 mm. latae, apice 3–4 mm., minores semicylindricae, infra ore obliquo applanatae, infra apicem rotundatae. Spiculae in oribus obliquis spatharum orientes haud ex basi, non pedicellatae, usque ad basin floriferae, floribus distichis, plerumque 15 24 (v. Tab. IV, Fig. 17) sed in spica terminali duplo pluribus quam in spicula laterali adjacenti, numero saepe 30. Spathellae rhachin amplectentes excentricae late naviculiformes valde venosae uno latere reflexae sed in apicem acutum inflexum productae. Involucrum cupuliforme excentricum ad rhachin unilateraliter inter spathellas duas consequas adnatum (v. Tab. IV, Fig. 18). Flores masculi vix aperti ovales 3 mm. longi, $2\frac{1}{2}$ mm. crassi (v. Tab. IV, Figg. 19–20). Calyx 1.8 mm. altus solum tertia parte tripartitus, segmentis obtusis, crasse 9–11-venosis, sinibus latis rotundatis (v. Tab. IV, Fig. 21). Corollae segmenta apice separata, acuta, deorsum connata, obscure ca. 23-venulosa. Stamina 2 mm. longa, sagittata, filamentis crassis atrobrunneis basi inter se connatis cupulam carnosam formantibus, ad apicem versus angustatis; antheris ca. 1.8 mm. longis, albis, versatilibus, prope apicem affixis, deorsum bipartitis (v. Tab. IV, Fig. 22). Pistillodium ex ovarii rudimento hyalino et 3 segmentis atrofuscis appressis subulatis constans (v. Tab. IV, Fig. 23).

Of this interesting species excellent specimens are at hand from Asahan and Tapianoeli, Sumatra, as follows:

Rahmat 6172 (type for monoecious or "female" plant, 16 sheets in Herb. Mich.); vernacular name *hotang saboet;* Tangga 2, District Pagar Batoe, Subdivision Habinsaran, Tapianoeli. Lowest spathe smooth.

Rahmat 7709, also monoecious; vernacular name *hotang saboet;* vicinity of Loemban Ria, Asahan. Lowest spathe smooth or sparsely spinulose.

Rahmat 7616; used for description of fruit; vernacular name *hotang*

timoek; vicinity of Loemban Ria, Asahan. Agrees with the type in the lowest sheath being smooth, but has instead of a simple triangular second involucre (when this structure is not a complete annulus) one with two parallel linguiform appendages, which may fuse laterally. Such a difference need hardly be considered of taxonomic value, since in the palms vestigial structures appear to be more variable than those which are functional. They may even be present or not present in different parts of the same plant.

Rahmat 7340 (type for male plant, 17 sheets in Herb. Mich.); vernacular name *hotang saboet;* vicinity of Hoeta Bagasan, Asahan. Spathes all smooth.

In the examination of the specimens here referred to *C. leiospathus* no characteristic has come to light of greater interest than the dimorphism of the male flowers and the pollen. The monoecious plant (corresponding to the functionally pistillate plant of most Calami) bears male flowers of narrowly cylindrical form with no pistillodium, with anthers attached near the apex, and with large pollen grains. The purely staminate plant, on the contrary, has oval flowers with a three-parted pistillodium, anthers attached near the middle, and small pollen grains. (Compare Pl. III, Fig. 10, and Pl. IV, Fig. 24.) It appears likely that the unexpected differences between the sex forms have a genetic basis within the species, but to avoid confusion that might arise from possible mixture of material belonging to different species separate type specimens are indicated for the monoecious and the staminate plants. Nomenclatorially, *C. leiospathus* should be interpreted by the type specimen of the monoecious plant.

University of Michigan

PLATES I-IV

EXPLANATION OF PLATE I

Calamus leiospathus, sp. nov.

All figures × $\frac{1}{3}$; drawn from the type material of the so-called "pistillate" (actually monoecious) plant (*Rahmat 7709*).

Fig. 1. Sheath, showing at top nude area extending downward from the back of the petiole, and the lack of a conspicuous swelling at the base of the petiole

Fig. 2. Part of frond, showing irregularly aggregated leaflets and the bristles on three veins of the upper surface

Fig. 3. Apex of frond, showing strongly armed cirrhus, a feature in which subgenus Calamoxleya resembles Daemonorops

Calamus (*Calamoxleya*) *leiospathus*, sp. nov. Details of leaf

EXPLANATION OF PLATE II

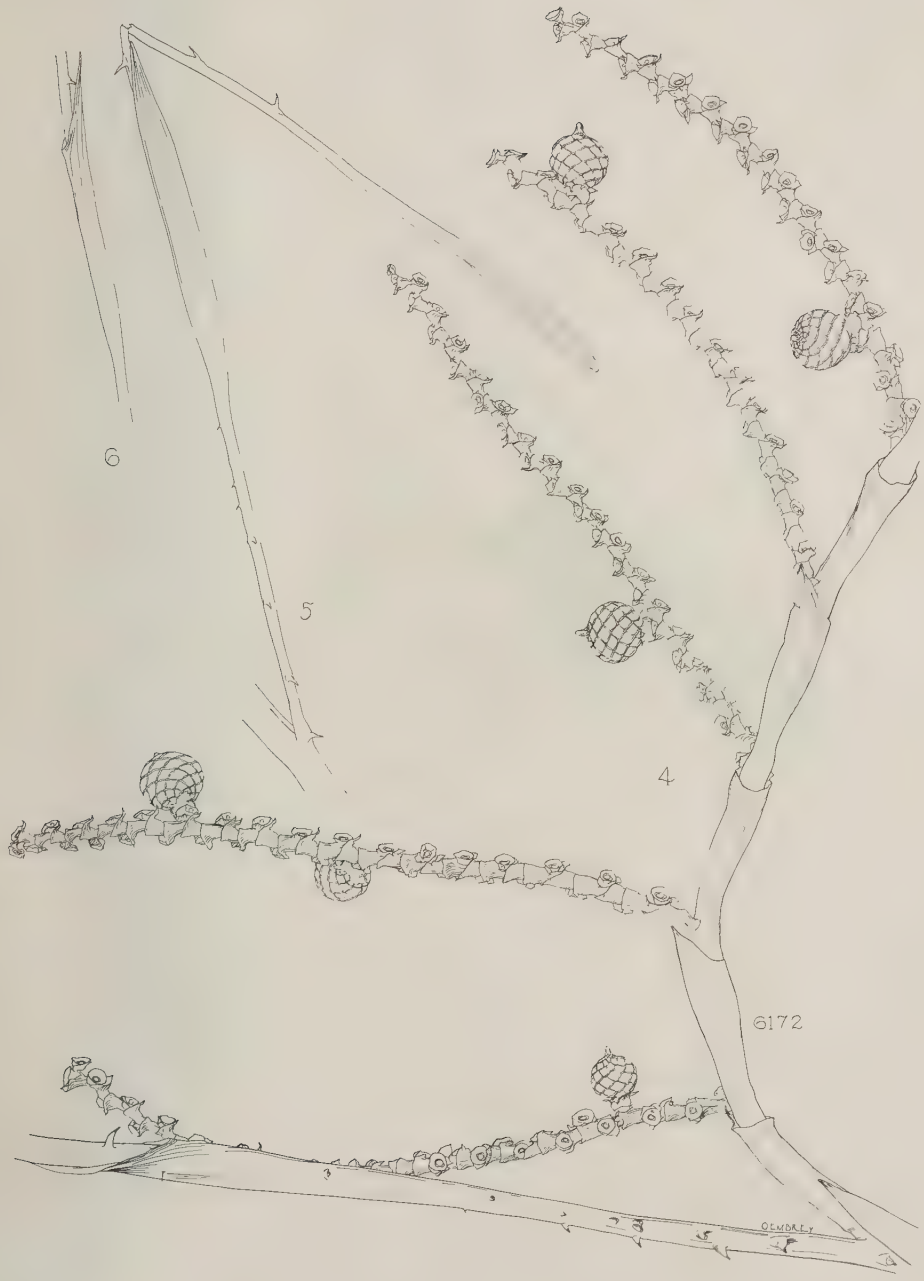
Calamus leiospathus, sp. nov.

All figures × 1; drawn from a "pistillate" (i.e. presumably monoecious) plant (*Rahmat 6172*).

Fig. 4. Part of spadix, showing the almost or entirely unarmed spathes and the spikelets from which most of the partly developed pistillate flowers have fallen. Note that many of the "involucres" (as, following Beccari, I have designated the structures bearing laterally the areole of the "sterile" flowers) contain a partly developed second involucre around the scar of the pistillate flower; it varies from a perfect annulus through a 3-, 2-, or 1-lobed structure to a mere vestige and is frequently completely absent

Fig. 5. The morphologically terminal portion (caudicula or rudimentary flagellum) of the spadix, weakly or hardly armed, with well-developed spathes

Fig. 6. Lower spathe of the vestigial flagellum, from side



Calamus (*Calamoxleya*) *leiospathus*, sp. nov. Details of ♀ inflorescence

EXPLANATION OF PLATE III

Calamus leiospathus, sp. nov.

FIG. 7. Parts (× 3) of spikelet of monoecious plant from which the flowers have fallen: left, below, and right, middle, involucre from side, showing areole and scar of solitary male flower; left, middle, involucre from side, showing areole with scars of 3 male flowers; left, above, and right, above and below, view into the involucre, showing the irregularly annular (bilobed) second involucre (*Rahmat 7709*)

FIG. 8. Male flowers from monoecious (so-called "pistillate") plant (× 6). The two unopened buds (at left) with long narrow calyces may not inconceivably represent lateral flowers from areoles with three scars, such as that shown in the middle of Figure 7, left, but it is quite as likely that the calyx becomes spread out and depressed when the flowers open, as in the three more mature flowers shown at right. The male flowers had all fallen from the scars and very few could be found (*Rahmat 7709*)

FIG. 9. Male flower laid open (× 6), showing the noncartilaginous filaments hardly if at all united at base, and the dehisced anthers attached near or below the middle

FIG. 10. Apparently functional pollen grains (× 150) from the male flower shown in Figure 9 (*Rahmat 7709*)

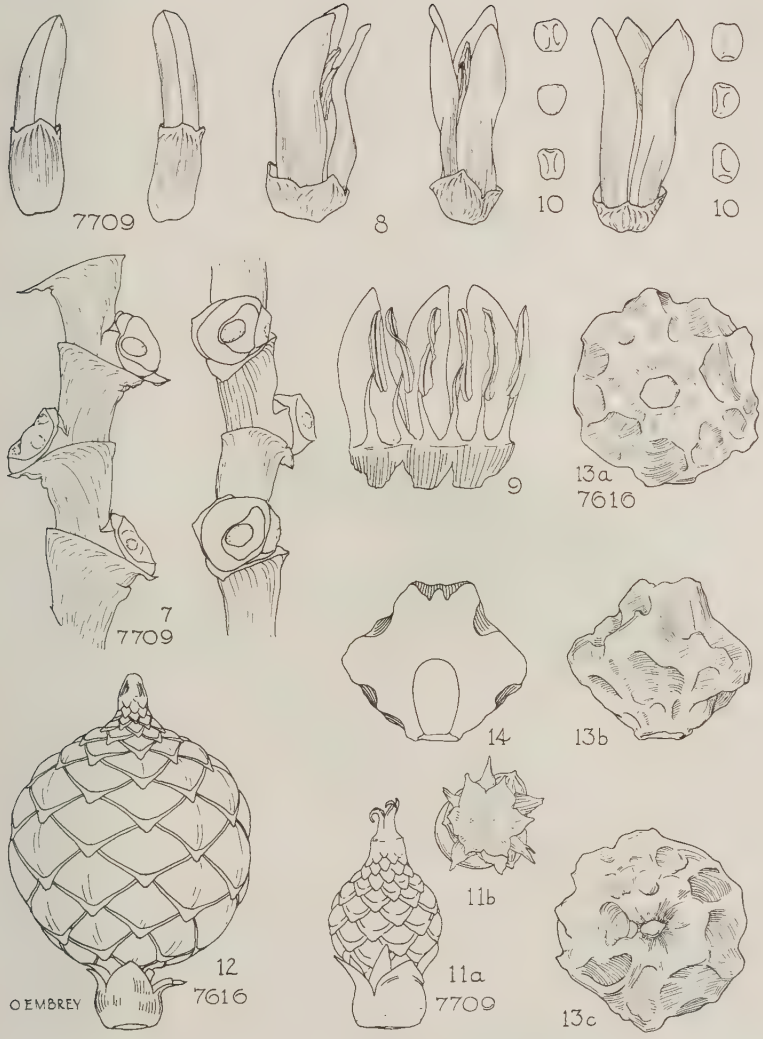
FIG. 11a. Developing pistillate flower with persistent perianth (× 3)

FIG. 11b. Vertical view of same with ovary removed to show firm 6-parted staminodial cup (*Rahmat 7709*)

FIG. 12. Mature fruit (× 3) from *Rahmat 7616*

FIG. 13 a, b, c. Endosperm of same, in polar and lateral aspects

FIG. 14. Vertical section of endosperm (× 3), showing embryo (*Rahmat 7616*)



Calamus (*Calamoxleya*) *leiospathus*, sp. nov. ♀ and associated ♂ flowers: fruit and seed

EXPLANATION OF PLATE IV

Calamus leiospathus, sp. nov.

All figures from *Rahmat 7340*.

Fig. 16. Part of the unarmed staminate spadix (× 1), showing the entirely smooth spathes and the merely vestigial sterile terminal part

Fig. 17. Part of same (× $3\frac{1}{2}$), showing origin of spikelets at about the level of the spathe orifice

Fig. 18. Fragments of spikelets (× 4), showing spathellae and involucres, and scars from which the staminate flowers have fallen

Figs. 19–20. Apical and side views of unopened staminate flower (× 4)

Fig. 21. Calyx of staminate flower laid open (× 4)

Figs. 22–23. Corolla of staminate flower removed, showing cartilaginous blackish staminal cup and versatile anthers attached far above middle (× 4). The pistillodium has a minute stipe and three separate, but appressed, vestigial carpels

Fig. 24. Pollen grains (× 100). Although the anthers from which the pollen was obtained had not yet dehisced, the grains were probably nearly mature. Their size, which is much smaller than that of the grains from staminate flowers of the monoecious plant, is therefore very remarkable (cf. Pl. III, Fig. 10, and Pl. IV, Fig. 24, allowing for different reduction). The grains in the latter are twice as long and several times as bulky as those in the former. So great a discrepancy in the pollen, and likewise the very different form and morphology of the male flowers borne by the two types of plant (i.e. monoecious and purely staminate), indicate some very remarkable genetical condition in the Calami, with respect to the inheritance of the sex forms, or else a failure to associate correctly the sex forms belonging to the same species

Calamus (*Calamoxleya*) *leiospathus*, sp. nov. Details of ♂ inflorescence and flowers

VARICOSPORIUM ELODEAE KEGEL, AN UNCOMMON SOIL FUNGUS

ERNST A. BESSEY

IN THE course of the summer foray of the Mycological Society of America, at and near Duchesnay, Quebec, in August, 1938, the writer collected several soil samples. One such sample from a good stand of *Abies balsamea* and *Betula papyrifera* near Lac St. Joseph yielded several interesting fungi. A bit of the now dry soil was placed, on October 19, 1938, in a sterile Soyka dish partly filled with sterile distilled water, and two sterilized hemp seeds were added. Some weeks later a thin growth of hyphae occupied areas near the hemp seeds at or near the surface of the water and extending 4 to 6 mm. On this mycelium were borne the peculiar conidia of *Varicosporium Elodeae* Kegel, most of them submerged just beneath the surface of the water, but a few in the air, where they formed little tufts.

No sharp distinction between conidiophores and vegetative hyphae was possible in the material under observation. The terminal portions of main hyphae or of lateral horizontal or vertical branches become somewhat thickened, up to 3 μ in diameter, and remain straight or become somewhat curved. From these there arise branches at right angles or more acute angles, often on one side only, and these in turn bear similar branches. At the point of attachment they are rounded to a narrow, very short isthmus or they are completely sessile. The branching may become quite complicated and, in general, the branches lie nearly all in the same plane. The resulting structures frequently resemble Chinese printed characters, as is shown in Figures 1 and 2. The main axis and the branches of the first and succeeding rank are distantly septate at first, but the septations become more numerous as the spores become more mature (Fig. 1*A*, young spore; 1*D*, mature spore). The contents of the cells are very finely granular or even almost homogeneous in appearance, but there may be a few coarser granules also. With age

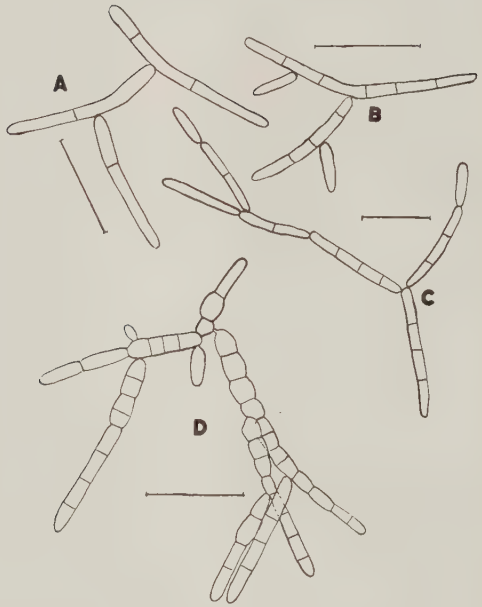


FIG. 1. *Varicosporium Elodeae* Kegel; spores of various forms and ages. *A* and *B*, young spores; *C*, rather mature spore; *D*, mature spore. Each scale represents 25 microns

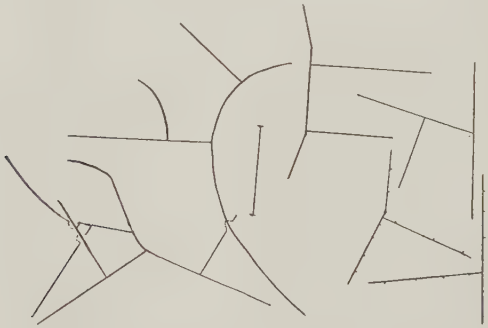


FIG. 2. Diagrams showing spores of various sizes and modes of branching. The dots beside two of the figures indicate points of septation. The central scale represents 25 microns

the main axis and the longer branches become constricted into segments of 3 to 5 cells each, so that ultimately the system resembles a chain of several-celled spores with branches of the same nature. The length of the main axis ranges from about 40 to 100 μ, with a thickness of about 3 μ. The whole system is hyaline.

Kegel [1] described this fungus in 1906 as *Varicosporium Elodeae*, gen. et sp. nov. He found it growing saprophytically upon dead or dying shoots of *Elodea canadensis* used by him in physiological studies on that plant at Göttingen, Germany. His figures match in almost all particulars the spores found by the writer. Some of his spores were a little longer, and some attained a diameter of 4 or even 5 μ. He interpreted the main axes as conidiophores. He placed the organism in the Fungi Imperfecti, in the section Hyalophragmiae of the Moniliaceae, in which section are found the genera Ramularia and Septocylindrium. Varicosporium has no close affinity with these genera, but since the families and tribes of the imperfect fungi are admittedly artificial "form" groups no criticism should be made of Kegel's disposition of his new genus.

Apparently the fungus is rare or has not been recognized, for the available mycological literature and abstract journals have no reference to it aside from Kegel's original paper.

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[1] Kegel, Werner, "Varicosporium Elodeae, ein Wasserpilz mit auffallender Konidienbildung," *Ber. deutsch. bot. Gesellsch.*, 24 : 213–216, 3 figs. 1906.

ANATOMY OF *URGINEA MARITIMA* (L.) BAKER

DOROTHY CHAPMAN CARPENTER

URGINEA is distinguished from Scilla in Engler and Prantl (10) by its compressed angular seeds and deciduous perianth segments; in Scilla the seeds are conical or obovate and the perianth is persistent. *U. maritima* (L.) Baker (*S. maritima* L., *U. Scilla* Steinh.) is found in the Canaries and along the shores of the Mediterranean Sea from Spain to Syria.

From the anatomist's standpoint three features of this plant are of particular interest. One is the presence of a cambium, which extends as a ring in the cortex of the stem plate and produces on the inner side amphivasal bundles which are scattered in parenchymatous ground tissue. Scanty parenchyma is formed on the outside. The second is the group of bulbils on the outer surface of each bulb scale by which vegetative reproduction takes place. They arise from the intercalary meristem of the scale base, where they remain connected with it as the scale grows by promeristematic strands, which later become vascular. Each bulbil has a meristem which cuts off small scales as the bulbil develops. The third feature is the method of splitting of the terete leaves by which they give rise to the flat basal part of the leaf. For varying lengths at the tip they are round and solid. Then, as they grow basally from the meristem of the stem plate, the meristem changes from round to the strap-shaped intercalary meristem of the leaf base. As a result the leaf tip splits, and in all future growth the leaf is flat and ribbon-like (3).

The material of *U. maritima* used in this study was originally introduced in 1910 from the Reale Giardino Botanico in Palermo, Sicily, by the Botanical Gardens of the University of Michigan, where the species has been grown since that time.

GENERAL CONSIDERATIONS

The bulb of *U. maritima* may reach a diameter of one decimeter and weigh as much as two kilograms. At its base there is a stem

plate, in part meristematic, which gives rise to leaves and flower stalk and to a fibrous root system. The checked parts in Figure 1 (Pl. I) are meristematic; the solid black region is the cambium. The fleshy bases of from ten to twenty two-ranked lanceolate gray-green leaves compose the greater part of the bulb. The leaves turn brown at the tip and die back slowly as they grow older, and the next younger scales successively become the outermost. As a scale dies and peels off, its own bulbils fall to the ground and root. The bulbils of the next scale are then uncovered, for their outstanding morphological peculiarity is that they are borne not in an axillary position, but on the outside of the scale.

Each year the stem plate produces one flower stalk, which bears a terminal raceme of numerous small green-striped white flowers (4). The angular black seeds germinate readily in the soil, very much as do those of Allium (12), and the seedlings yield bulblets similar in appearance to the asexually produced bulbils which have dropped to the ground and formed roots and leaves.

THE BULBIL

In each scale the bulbils vary in arrangement, but often have the aspect of one at the apex of the group and the rest in two irregular rows. A vascular strand connects each one directly with the stem plate or indirectly by fusion with the strands of subsequently formed lower bulbils. There is no uniformity in the vascular supply of the bulbils; each scale shows marked variations.

As the scale develops basally from the meristem the meristematic strand from the oldest, uppermost, bulbil persists with or without branching or giving rise to younger, newer, bulbils and eventually is differentiated from above downward as a vascular strand. The varying course of the strands and arrangement of the bulbils on different scales are shown in Figures 2–14. A bulbil is roughly triangular (Figs. 3 4), and a hollow is formed in the scale beneath it by the pressure of its growth (Fig. 5).

The bulb of a typical plant which was completely dissected is shown in Figure 2. One group of immature bulbils is present on the outermost scale, the largest at the top. On the first inner scale is a group of five bulbils smaller than those on the outside (Fig. 6); the second scale from the outside also has five (Fig. 7); the third has eight (Fig. 8); the fourth has three (Fig. 9); the fifth has but

one bulbil at this stage (Fig. 10); and the sixth scale has, near the base, but one barely perceptible swelling, which is the beginning of a bulbil (Fig. 11). This sixth scale continues, as the youngest leaf, to extend above the top of the bulb. Scale seven has no visible bulbils and is almost paper-thin at the base; the split in the eighth scale (Fig. 12) continues almost to the stem plate, with the flattened leaf rolled tightly around itself. Scale nine is similar, except that the split in it extends down to the stem plate; scale ten (Fig. 13) is represented by a solid round tip, except at the base, where a split is just beginning to appear. The innermost structure of the bulb (Fig. 14) is four millimeters long and is the solid tip of the youngest leaf.

Long before a bulbil is in any way apparent on the surface of the scale divisions occur in certain scale cells as they are being formed from the meristematic region of the stem plate. These divisions continue in a very small area, and as a result form a bulbil instead of ordinary scale tissue (Fig. 15). During the early differentiation of bulbils, which are then so young as to be barely visible to the naked eye, they are connected by procambial tissue continuously with the promeristem of the stem plate. As the scales become older there is progressive differentiation of the strands into xylem and phloem from above downward. But so long as the basal growth of the scale continues, the base of the strand remains procambial.

Serial cross sections were made through the youngest bulbil visible to the naked eye, which appeared as a slight swelling on the surface of the scale with no differentiation of parts. A section directly through its center shows the meristematic region which has appeared in the scale (Fig. 16). A somewhat older bulbil, which had differentiated enough for its tip to be entirely unattached to the bulb scale, was also studied in detail. The extreme tip is of undifferentiated parenchyma. At a lower level the meristematic region which cuts off the young scales is apparent; three meristematic strands go from the bulb scale through the bulbil base up to the meristematic region (Fig. 17).

A longitudinal section through the center of a bulbil old enough to have a stalk attaching it to the scale, but not yet mature, shows that xylem and phloem are being differentiated. Promeristematic strands continue up to the central meristematic region, which is deep within the bulbil, beneath the four scales which have already

been formed (Fig. 18). A transverse section through a mature bulbil stalk attachment shows the stalk to be of smaller parenchyma cells than those of the scale.

A large number of mature bulbils dissected just after being shed proved to have the same general anatomy. A median longitudinal section shows that the four outer scales do not have solid tips. They extend to the top of the bulbil, each younger one being slightly longer than the last. Their epidermal surfaces are of similar rectangular cells, and there are no stomata. The fifth scale inward has a solid tip which reaches somewhat beyond the top, having mechanically, through continued growth, forced its way through the outer scales which originally extended over it. Within it, and at about half its length, is the sixth leaf, of which only a part of the solid tip has been formed. Each scale rises at the base from the stem plate, which is a well-differentiated region (Fig. 19).

During the last ten years considerable study has been made of reproduction in many bulbous monocotyledonous forms by means of small vegetatively produced bulbils. Chouard (6–7) mentions several of the various types found in the Scilleae. Some, such as *Muscari racemosum* Mill. and *Ornithogalum nutans* L. produce bulbils around all of the outer base of the bulb; these bulbils later become detached and develop independently. More frequently, however, bulbils are produced singly on the inside at the base of an outermost scale, i.e. in a demonstrably axillary position. Here they remain until freed by the decomposition of the outer scale or form leaves and roots and develop *in situ*. This type is found in *Scilla verna* Huds., *S. peruviana* L., and other species. Neither of these manners of bulbil formation — and they are not necessarily fundamentally different — is similar to the mode of production in Urginea, however, for in the two former types the bulbils arise from stem tissue, whereas in Urginea they arise from cells on the outer surface of the bulb scales, far above the level of the stem plate.

In Erythronium (15) and Tulipa (2) a small bulblet is carried downward into the earth on the end of a "dropper," which is a modified continuation of the base of the foliage leaf. In some species this bulblet produces a single foliage leaf the next year, and it is in turn prolonged at the base into a dropper, which carries the terminal bud downward into the soil. This may be repeated for several years, as in *Tulipa sylvestris* L. and *T. saxatilis* Sieber. In

other kinds the bulblet elongates each year and produces a flower scape. In such a plant the dropper for the next year's growth is formed from a lateral bud and penetrates but a short distance beneath the soil surface (Tulipa, garden variety).

L. Daniel (8) found that, when *Allium Porrum* L. is grown in light of low intensity, it flowers late and there are fasciations and proliferated flowers in the inflorescences. In some of the proliferated flowers bulbils occur at the base of the proliferations, and in others, as is a common occurrence in *Cyperus dentatus* Torr. and *Juncus pelocarpus* Mey., they may replace the spikes of flowers.

The bulbils in *U. maritima* seem different from any of those mentioned by other investigators. Their occurrence is in a single vertically arranged group on the outer surface of every scale. They are not connected with the inflorescence in any way, nor are they formed from the stem plate. Both an annual stalk and the bulbil group on each scale appeared on all the mature plants available for study.

TRANSITION FROM ROOT TO STEM OF PLANT FORMED FROM A BULBIL

A four-month-old plant grown from a bulbil was sectioned to show the root–stem transition; it had four roots and one leaf, which was five centimeters long. The two outermost scales were dry and brownish and had partly died back toward the base, and so were removed. The young solid round leaf has four collateral vascular bundles, with the endarch xylem innermost. The general tissue is parenchymatous, with a thin-walled epidermis and scattered stomata. At the level of the top of the bulb the solid terete leaf has six promeristematic strands arranged in a circle, and the scale around it has six promeristematic strands alternating with six vascular bundles. A short distance below this the tip of a still younger leaf appears in the bulb center; it contains one promeristematic strand, and its general tissue is parenchymatous. There are three scales around it, the innermost of which has one bundle and four promeristematic strands. The next outermost has seven bundles and seven alternating promeristematic strands; the outermost scale, eleven bundles (Fig. 20).

The tip of the stem plate is entirely meristematic; the bundles in the scales around it remain the same. At a slightly lower level

the central bulb area contains four promeristematic strands and one bundle, which are arranged in a ring around the large central meristematic area. Numerous starch grains are stored in the outer scale. Some are very large, and their lobed, forked, round or angular hila may be easily seen. The vascular system undergoes change just below this level. In the bulb center two promeristematic strands on each side unite with each other, and the promeristematic area, which was in the center at a higher level, curves out as a strand to make a fourth in the ring. A small amount of xylem is differentiated in one of the pairs of united meristematic strands. The bundles in the scales turn in toward the bulb center, and as the level of the union of scale bases with stem plate is reached no splits between the scales are visible.

The cells of a large part of the outer region contain masses of small round bodies, which take a deep pink stain with safranin. These masses are soluble starch; as they gradually accumulate in a cell the large starch grains which formerly filled it are correspondingly fewer. In the normal state the starch grains do not gelatinize because of a cellulose protective coating which prevents water from reaching the starch substance (13). It is possible that at the basal meristematic region of the stem plate there is given off an enzyme which makes soluble the outer coating of the starch grains stored in the scales. This soluble starch probably provides the energy for the cell formation and growth which occur in the stem plate.

At lower levels of the bulb the three central areas of xylem, phloem, and undifferentiated parenchyma each divide in an inverted V, and several of these subdivide, forming ten small bundles with xylem and five promeristematic strands. Just below this a cambium forms an interrupted ring around the central part of the bulb. In the very center are the regular primary tissues, and outside them, reaching the cambium, are the secondary tissues.

In a plant but four months old the amount of secondary tissue is small; it consists of a few amphivasal and collateral bundles and several still promeristematic bundles scattered in parenchyma tissue. The cambium extends downward in the bulb for a short distance. Below it a number of thick vascular strands of primary origin descend from the central region. The exterior of the bulb is uneven in outline and rough where portions of it have sloughed off because of contact with the soil. The vascular strands gather into three definite

groups, and from them arises the vascular tissue which supplies the adventitious roots (Fig. 21). The region of gelatinized starch grains, which is smaller, finally disappears as lower levels are reached. The roots grow down through the bulb stem-plate base and out into the soil.

There are two types of vascular systems in the roots. One has five or six protoxylem "rays" coming off from three or four large metaxylem vessels in the center of the root, with patches of phloem in between the rays. The other type, which was found in only one of several dozen roots that were examined and which is polyarch, has nine small groups of protoxylem, each consisting of from one to three tracheids arranged in a circle, alternating with nine phloem groups. An endodermis differentiates a few cells at a time in the cortex of each root.

In a mature plant several years of age in which the bulb is five to eight centimeters in diameter the proportion of tissues of the stem plate is different from that in the young plant just developing from a bulbil. The greater part is secondary in origin; there is a small amount of primary tissue in the center, with several wide vascular strands arising from it (Fig. 22, Pl. II). The cambial cells are vertically elongated. In cross section the radial dimension is far less than the tangential, and the cells are much smaller than adjoining parenchyma cells. They do not have tapering ends. The cambium extends in a circle within the cortex, and the divisions within it are chiefly tangential. Most of the tissue formed by it is toward the center of the stem, with but a scanty amount of parenchyma on the outside.

The older secondary bundles, which have well-differentiated xylem and phloem, are toward the stem center (Fig. 23). Nearer the cambium the younger bundles have little or no xylem or phloem yet visible. For a distance inside the cambium the interfascicular parenchyma shows its radial arrangement. The vascular bundles arise at intervals by the divisions, first in the radial and then in all planes, of mother cells which are formed by the cambium (Fig. 24). Eventually phloem and xylem are differentiated, and a mature functional amphivasal bundle exists. This type of secondary growth in Monocotyledones is very slow and may continue almost indefinitely.

THE CAMBIUM OF THE MONOCOTYLEDONES

Whereas the Monocotyledones as a class do not have extensive secondary growth as a result of interfascicular cambial activity, intrafascicular cambium does occur in many monocotyledonous plants. The first observation appears to be that of Russow (14) concerning cambium in the vascular bundles of *Hemerocallis fulva* L. Subsequently, according to Arber (1) in her series of articles on the cambium in Monocotyledones, one or more instances of intrafascicular cambium have been recorded in the following families: Typhaceae, Potamogetonaceae, Scheuchzeriaceae, Gramineae, Cyperaceae, Palmae, Araceae, Commelinaceae, Liliaceae, Dioscoreaceae, Iridaceae, Musaceae, and Zingiberaceae. This leaves but three of the cohorts into which Bentham and Hooker divide the Monocotyledones, the Triuridales, the Synanthae, and the Microspermae, in which such a cambium has not as yet been reported.

In addition to an intrafascicular cambium a special type of secondary thickening occurs in a few monocotyledonous forms in which a cambial layer is formed from the meristematic parenchyma of the pericycle or innermost cortical cells, which produces on its inner side whole amphivasal or collateral bundles embedded in ground parenchyma, and on the outer side small amounts of parenchyma. Reports have been made of such cambium in Dracaena, Aloe, Yucca, Agave, Cordyline, Dasyliron, Testudinaria, Dioscorea, Aristea, and related genera. A similar cambium was found in the stem plate of *U. maritima*, the first to my knowledge to be reported in a liliaceous plant which retains a nonwoody succulent bulb its entire life.[1]

SEED GERMINATION AND SEEDLING PLANT

The fruit of *U. maritima* is a capsule, and there are about four black sharply angled seeds in each of the three locules (4). They germinate readily by either of two methods. In the majority growth occurs first at the lower and middle regions of the cotyledon, forcing the root and cotyledon through the seed coat. When the cotyledon is from four to six millimeters long it begins to turn downward, with the bending occurring in the elongating region just above the stem

[1] After the writer's work on Urginea had been completed *Veratrum viride* Ait. was reported by Cheadle (5) as having such a cambium.

plate (Figs. 25–27). In a short time the root, which has root hairs over a large area, points downward. Equal growth then takes place in two regions, one a short distance above the stem plate and the other just below the seed. The result is that the bent cotyledonary portion is pushed up above the surface of the soil while the remainder of the seedling is still beneath.

Ten days after planting the first seedlings appear above the ground. The bent cotyledon slowly straightens, and the seedling becomes upright (Figs. 28–32). The second type of germination begins in the same manner as the first, and is the same up to a length of four to six millimeters, when the basal portion of the plant begins to turn downward. Whereas in the first type the bending occurs in the elongating region just above the stem plate and growth afterward takes place there and below the seed, in the second type the bending downward occurs only in the region below the seed. But no elongation takes place at any time afterward in the region directly below the seed, all of it being above the stem plate. Therefore no loop is formed; instead the cotyledon and seed are forced straight upward through the soil (Figs. 34–42).

There is great variation in the time lapse before other roots appear on a seedling, but usually a second one is formed three or four weeks after germination. It arises from the stem plate beside the radicle, which after a short time usually shrivels and dies, and is similar to it in shape and structure (Fig. 33). Other roots appear at short intervals, six being found on one plant three months old. At any time after three weeks a small slit appears in the cotyledon above the stem plate, and through it protrudes the solid round tip of the first leaf. Growth of the cotyledon ceases, and the new leaf grows rapidly from the base.

Serial cross sections were made of several seedlings six months old. In general structure they are similar to young plants formed from bulbils. There are minor differences of bundle number in the young solid leaf tips, and either three, four, or five protoxylem rays come off from the three or four metaxylem vessels in the roots. Both plants grow similarly from a basal meristematic region in the stem plate, form a cambium, have leaves with solid tips and flat basal regions, and are otherwise alike.

EVOLUTION OF THE MONOCOTYLEDONES

In general, it seems to be agreed that the Monocotyledones have evolved from a dicotyledonous ancestry, probably from types close to the Ranalian level. Beyond that opinions differ greatly. It seems probable (9, 11) that true woodiness in Dicotyledones is primitive, and herbaceousness an advanced condition which has arisen independently in various groups, whole segments of the central cylinder having become transformed entirely into parenchyma in connection with the departure of leaf traces. When a cylinder is split up the cambium continues as an unbroken ring for a time, with the interfascicular portions forming parenchyma. Then as the plant becomes still more herbaceous the interfascicular cambium becomes less active and eventually disappears. Later the fascicular cambium also ceases to function, and the highest type of dicotyledonous bundle is found.

Loss of the cambium as an entire ring had probably already taken place in the herbaceous Dicotyledones before the Monocotyledones evolved. An intrafascicular cambium, however, remained in the ancestral Dicotyledones and would therefore be expected to occur in the Monocotyledones derived from them, as it actually does. The type of cambium found in a ring in such Monocotyledones as Dracaena, Aloe, and Urginea, is obviously different from that found in the Dicotyledones. Some investigators consider it an early development in the history of the Monocotyledones, which so successful a woody group as the Palmales reached long ago. Others regard it as comparatively recent.

Such plants as Veratrum and Urginea, which possess an active cambium but which remain herbaceous and succulent their entire lives, may also be viewed in two ways. They may possibly represent lines of evolution in which the cambium is just beginning to appear and in which it has not as yet reached its complete development, or, on the contrary, they may be plants which had woody monocotyledonous ancestry from which herbaceous types have again evolved, with the cambium still active but rudimentary in comparison with its former state.

Probably future investigations will disclose other Monocotyledones below the woody condition, with cambium in various stages of development. A study of such closely related genera as the woody

Agave and the herbaceous Manfreda might reveal many interesting facts. It is hardly possible that during the long-persisting rosette condition in the gigantic species of Agave there is nothing comparable to the cambium of Urginea. If it is present in true Agave (of the maguey type) and also in the herbaceous Manfreda, we would be presented with an interesting pair of undoubtedly allied plant types in which to trace persistence of cambium during retrogressive evolution or, conversely, its appearance *ab initio* in progressive evolution from the small herbaceous to the large woody type. Urginea, unfortunately, cannot clearly and certainly be associated with any woody type.

SUMMARY

1. *Urginea maritima* is a liliaceous plant of very unusual vegetative morphology, as is indicated by the two remarkable features that have been described involving the distribution of meristematic tissue. In view of the fact that the bulbil formation is equally remarkable, yet of a type that is not known to occur in any other plant and certainly cannot, therefore, be looked upon as a feature of phylogenetic importance, one should be cautious about too far-reaching an application in a phylogenetic argument of the findings with regard to the cambium.

2. Each scale bears on its outer surface a group of small bulbils which arise from the intercalary meristem of the scale base. As the scale grows they remain connected with the intercalary meristem by promeristematic strands which later become vascular. Each bulbil has an apical meristem which cuts off the small scales as the bulbil develops. Upon contact with the soil when mature each bulbil can produce another plant, vegetatively. This type of bulbil and its position are unique; bulbils are usually at the bulb base between scales, in an axillary position in the inflorescence or at the end of vegetative droppers. Plants formed by the growth of bulbils are very similar, anatomically, to seedlings of comparable size.

3. The stem plate of Urginea contains a cambium which forms secondary amphivasal and collateral bundles scattered in parenchymatous ground tissue. Scanty parenchyma is formed outside the cambium. The plant, however, remains fleshy and nonwoody its entire life. The greater part of the plant tissue is parenchymatous; no sclerenchyma was found in any region. All bundles of the leaf,

flower parts, and peduncle, and primary tissues of the stem are collateral, with the endarch xylem innermost.

4. The adventitious roots in cross section usually have five or six protoxylem rays coming off from three or four large metaxylem vessels in the root center, with phloem between the rays.

I wish to express appreciation to Dr. Carl D. La Rue, of the Botany Department of the University of Michigan, for suggesting the problem, and to Professor H. H. Bartlett, head of the Department, for inestimable aid.

University of Michigan

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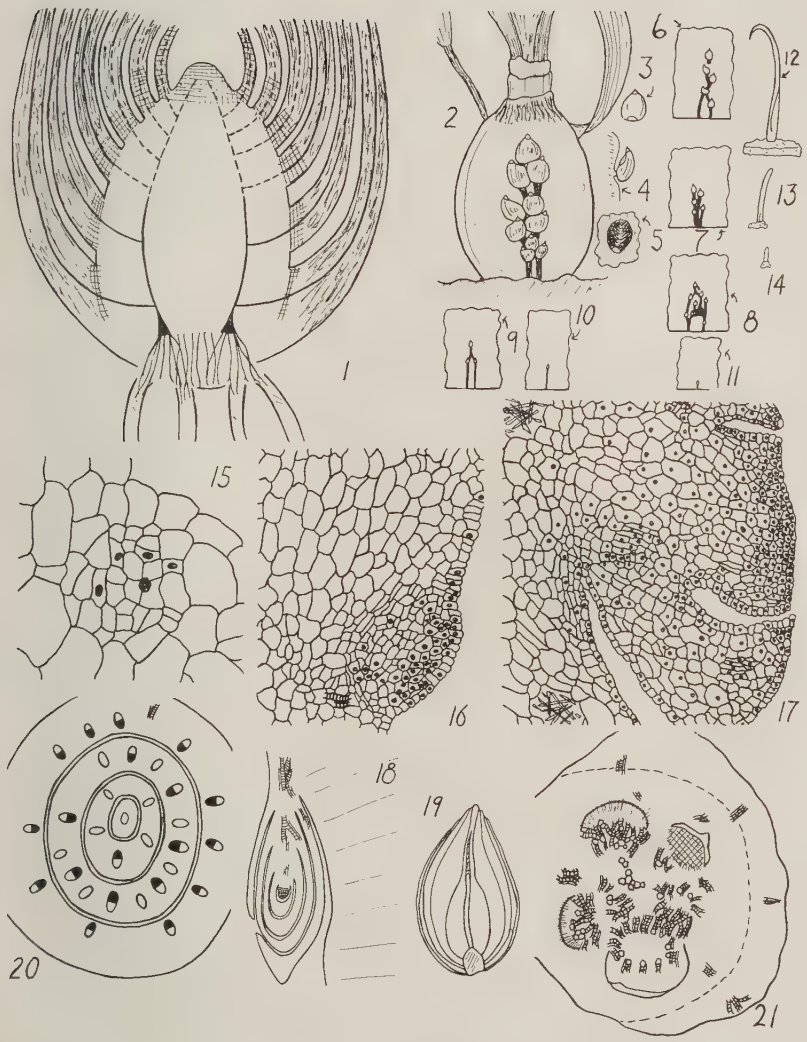
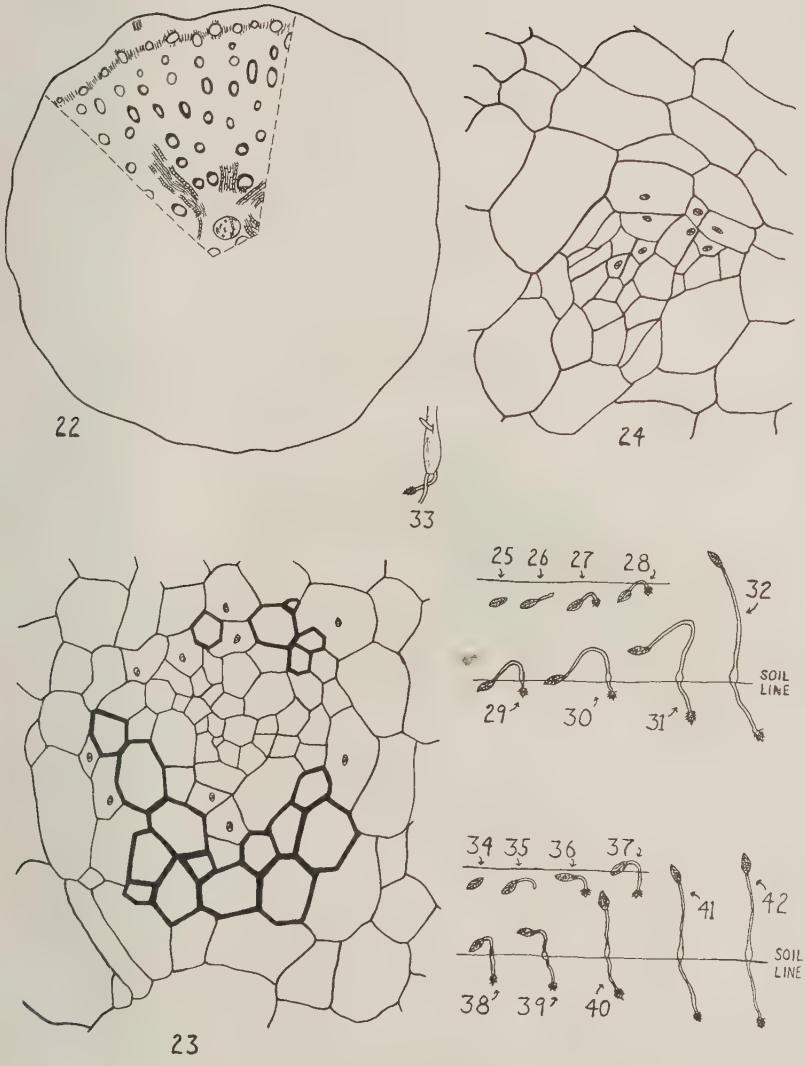


Urginea maritima (L.) Baker

FIGS. 1–19. Habit sketches and sections of bulb and bulbil formation

FIGS. 20–21. Transverse sections of root-stem transition of plant formed from a bulbil. Figure 20 is through tip of youngest leaf; Figure 21 shows vascular supply of adventitious roots



Urginea maritima (L.) Baker

FIGS. 22–24. Secondary bundles formed by cambial activity in the bulb stem plate
FIGS. 25–42. Two methods of germination of seed and seedling growth

SOME VEGETATIONAL ASPECTS OF BEAVER ISLAND, LAKE MICHIGAN

HENRY TOWNSEND DARLINGTON

BEAVER ISLAND (sometimes called Big Beaver) is the largest of a group of islands of the same name in Lake Michigan. The mean latitude for the center of the group is 45° 43′ N. and the mean longitude 85° 32′ W. (see Fig. 1). The islands vary greatly in size. The largest one is Beaver, with an area of over fifty square miles; the smallest ones, some of which are apparently unnamed, consist of little more than shoals. The nine largest, arranged in the order of decreasing size, are as follows: Beaver, Garden, High, Hog, Gull, Whiskey, Trout, Squaw, and Hat. Beaver Island is approximately nineteen miles west of the nearest shore line in Emmet County, Michigan. The smaller islands lie within a radius of twelve miles of Beaver Island, the nearest being Garden Island, less than one and one-half miles north and slightly east, and the farthest, Gull Island, which is due west.

In early September, 1922, the writer spent nearly a week on Beaver Island and, in addition, one-half day on Garden Island studying and listing the distribution of the higher plants and ferns. This work was done in connection with the Land Economic Survey, in charge of L. R. A. Schoenmann, with headquarters on Fox Lake (Pl. I, Fig. 1), near the center of Beaver Island.

Beaver Island is approximately thirteen miles long, with its greatest width slightly over six. The northern part is underlain by limestone formations which outcrop at points. Much of the interior is gently rolling, corresponding with the original glacial drift. The surface ranges from forty to eighty feet above Lake Michigan. Around the border are glacial sand and shingle beaches, on some of which the wave-cut terraces of glacial Lake Nipissing may be traced. Back of the shore line there is in places a zone of dunes, which reaches its highest development on the west side of the island (Pl. II). The highest point of this dune complex is known as Mount Pisgah. This

dune, which is west of Faunt Lake in the northern part of the island, is said to be two hundred feet high. Its topmost portion is believed to have been circled by the waters of glacial Lake Algonquin.

Beaver Harbor, in the northern part of the island (Pl. III, Fig. 1), is a landlocked bay opening like a horseshoe toward the east and possessing several natural advantages. On the west shore of the bay the rambling fishing village of St. James was established at an early date. Here climatic records were kept for a period of twenty-three years, from 1905 to 1927, after which they were apparently discontinued. As might be expected, the island has a more or less equable or maritime type of climate. This is indicated by certain aspects of the vegetation. The writer was surprised by the size and the vigor of beech (*Fagus grandifolia*). The average yearly temperature for the period recorded was 42.8° F., the mean maximum, 50.8° F., and the mean minimum, 35°. The greatest recorded extremes were 97° F. (in May!) and − 28° F. (in December). The mean date of the last killing frost was May 14, and of the first killing frost, October 13, which gives a growing season of 152 days. This is 14 per cent longer than the growing season in Emmet County, at approximately the same latitude. The average annual rainfall recorded was 24.66 inches, with the maximum in October and the minimum in March.[1]

Apparently settlement of Big Beaver has been more meager than was originally anticipated. The earliest highway constructed was that south of St. James (Pl. III, Fig. 2). This part of Big Beaver is rather level and sandy, a condition which necessarily forms a background (from a phytogeographic point of view) for the type of vegetation found there. Some of the less desirable land in the southern part is not readily accessible. The better areas of virgin timber were undoubtedly cut long ago, since settlements on the island by French Canadians began at a very early date, even preceding the settlement of the Pilgrims at Plymouth Rock.[2] The settlement of St. James, on the north end, was the original county seat of Emmet County. It became the center of extensive lumbering and fishing interests, and also headquarters of the Mormons [3] in this region, under the notorious

[1] For the climatic records given above the writer is indebted to Mr. H. M. Wills, of the United States Weather Bureau at East Lansing, Michigan.

[2] "A Short History of the Beaver Islands," *Michigan Pioneer and Historical Collections*, 32 (1902): 176–179. 1903.

[3] Swift, Ivan, "The Vanished Kingdom," *Michigan History Magazine*, 12: 443–449. 1928.

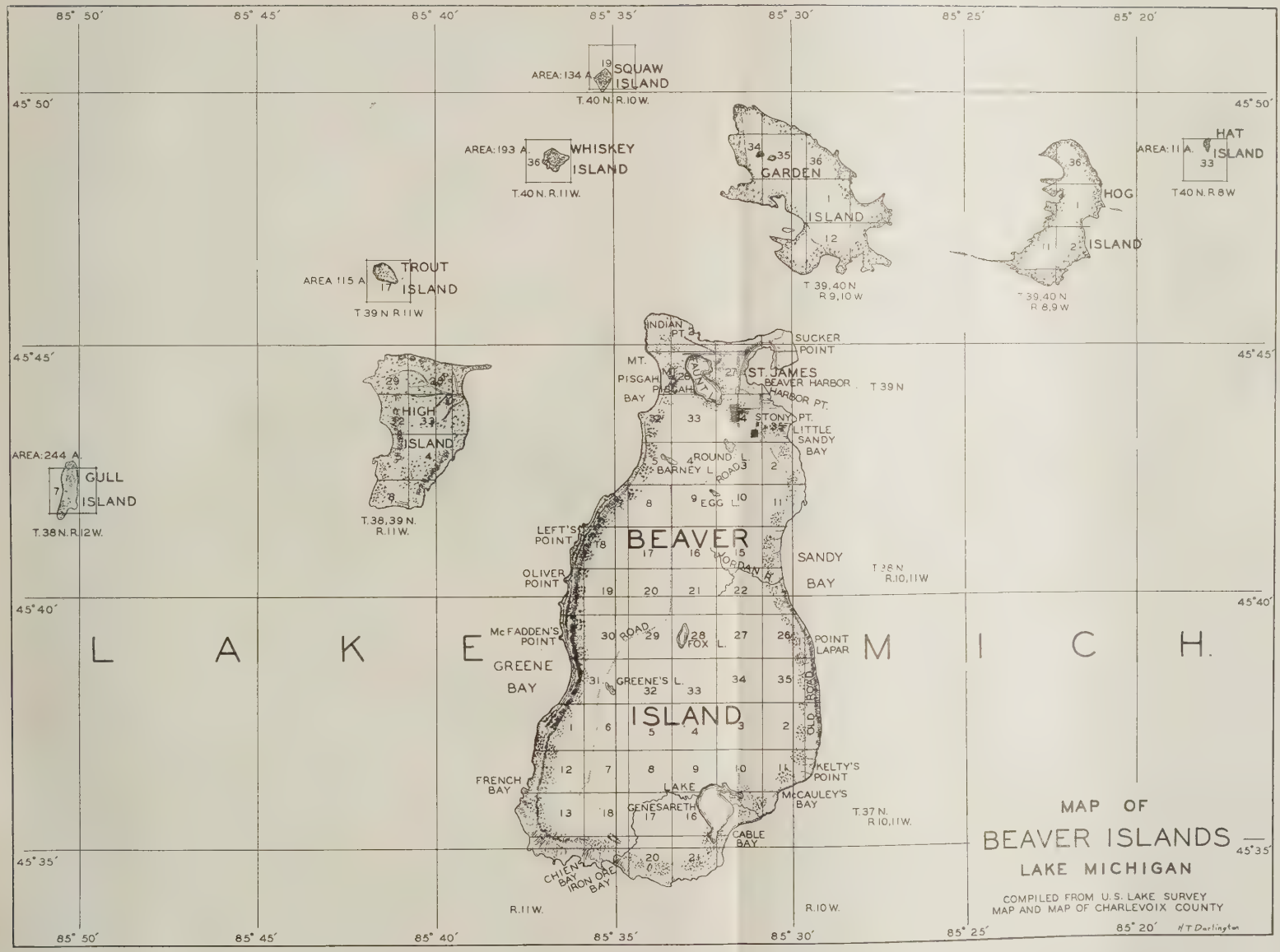

85° 50′
85° 45′
85° 40′
85° 35′
85° 30′
85° 25′
85° 20′
45° 50′
45° 45′
45° 40′
45° 35′
AREA: 134 A.
SQUAW ISLAND
T. 40 N. R. 10 W.
AREA: 193 A.
WHISKEY ISLAND
T. 40 N. R. 11 W.
GARDEN ISLAND
T. 39, 40 N. R. 9, 10 W.
HOG ISLAND
T. 39, 40 N. R. 8, 9 W.
AREA: 11 A.
HAT ISLAND
T. 40 N. R. 8 W.
AREA 115 A.
TROUT ISLAND
T. 39 N. R. 11 W.
HIGH ISLAND
T. 38, 39 N. R. 11 W.
AREA: 244 A.
GULL ISLAND
T. 38 N. R. 12 W.
INDIAN PT.
SUCKER POINT
MT. PISGAH
PISGAH BAY
ST. JAMES
BEAVER HARBOR
HARBOR PT.
T. 39 N.
STONY PT.
LITTLE SANDY BAY
ROUND L.
BARNEY L.
ROAD
EGG L.
BEAVER
LEFT'S POINT
OLIVER POINT
JORDAN R.
SANDY BAY
T. 38 N. R. 10, 11 W.
McFADDEN'S POINT
GREENE BAY
FOX L.
POINT LAPAR
LAKE MICHIGAN
GREENE'S L.
ISLAND
OLD ROAD
FRENCH BAY
KELTY'S POINT
LAKE
McCAULEY'S BAY
GENESARETH
T. 37 N. R. 10, 11 W.
CABLE BAY
CHIEN BAY
IRON ORE BAY
R. 11 W.
R. 10 W.
MAP OF
BEAVER ISLANDS
LAKE MICHIGAN
COMPILED FROM U. S. LAKE SURVEY MAP AND MAP OF CHARLEVOIX COUNTY
H. T. Darlington

FIG. 1

"King Strang." There are considerable stands of second growth, especially in the north-central and eastern parts of the island. Extensive tracts in the southeastern part have been cut over and burned. This area is being invaded by second growth, including willow and aspen, with white cedar and spruce in the wetter grounds. West of Lake Genesareth are considerable stands of swamp timber. The best farming and improved land lies in the northern half.

Throughout the island are stretches of swampy land, small areas of improved land or pasture, and several lakes. The two most important lakes are Faunt Lake, already mentioned, and Lake Genesareth (originally called Lake Galilee), near the south end. The latter has an area of about a thousand acres. Smaller lakes are Fox Lake, Egg Lake, Round Lake, Barney Lake, and Greene Lake (see Fig. 1). Of these, Fox Lake (Pl. I, Fig. 1) may be taken as typifying the general character of the vegetation and shore line around the smaller lakes.

The flora of the island is related closely to that of Emmet and Charlevoix counties along the Michigan shore line. Botanical interest naturally centers around the native flora. However, about seventy-five foreign species were noted by the writer, the majority in and near the small settlement of St. James. A few were found on Garden Island also, which for many years has had small lumbering interests. The distribution of the native vegetation is to be accounted for by the diversity of physiographic features, comprising upland forested areas (Pl. I, Fig. 2), open sandy stretches, dunes, cedar swamps, lake borders, marshes, and a more or less irregular shore line.

North and west of St. James there is a zone of sand averaging approximately one-half mile wide. This is covered by an open type of forest in which white pine, red pine, and red oak are dominant; these occur also along the low-lying shore of Beaver Harbor (Pl. III, Fig. 1). Scattered representatives of other tree species are found with those mentioned, the most noticeable of which are *Abies balsamea*, *Picea glauca*, *Betula papyrifera*, *Populus tremuloides*, *Populus grandidentata*, and *Ostrya virginiana*. Where the forest borders directly on the shore, common species are *Tsuga canadensis* and *Thuja occidentalis*. The low juniper, *Juniperus communis* var. *depressa*, is common on these sandy areas. Sometimes it grows in large circular patches, which are very attractive. In similar situations, but less

frequent, is the creeping juniper (*Juniperus horizontalis*), which often forms dense mats containing several square yards.

The dune topography varies from gently rolling ground to areas in which the dune complex becomes quite rough. An illustration of the latter type of topography occurs west of Faunt Lake and includes Mount Pisgah. On the top of this dune, vegetation is very sparse, but one of the surprises was the occurrence there of beach grass (*Ammophila breviligulata*), though it was not seen along the immediate shore line, where it might be expected.

At present, stands of virgin timber form a comparatively small proportion of the total area of Beaver Island. Where typical mesophytic woods occur the two most valuable tree species are *Fagus grandifolia* and *Acer saccharum*. Associated with these are *Tilia americana*, *Prunus serotina*, *Quercus borealis* var. *maxima*, and several woody species of secondary importance, such as *Acer rubrum*, *Prunus virginiana*, *Corylus cornuta*, *Ribes cynosbati*, *Ribes americanum*, *Sambucus racemosa*, *Lonicera canadensis*, *Taxus canadensis*, *Cornus rugosa*, *Viburnum acerifolium*, and *Parthenocissus quinquefolia*. A number of trees and shrubs occur here and there in mixed communities. Among these may be mentioned *Quercus alba*, *Quercus coccinea*, *Fraxinus americana*, *Juniperus virginiana*, *Salix nigra*, *Sorbus americana*, *Ulmus racemosa*, *Prunus americana*, *Cornus alternifolia*, and *Cornus candidissima*. A few in this list were not seen by the writer, but were reported by Cass Andrews, of the Land Economic Survey, who spent several weeks on the island.

The herbaceous flora of the woodland areas shows affinities to that of both the southern and the northern districts of the Michigan mainland. The following are typical: *Thalictrum dioicum*, *Circaea latifolia*, *Hepatica acutiloba*, *Viola eriocarpa*, *Polygonatum pubescens*, *Smilacina stellata*, *Caulophyllum thalictroides*, *Arisaema triphyllum*, *Solidago latifolia*, *Adiantum pedatum*, *Athyrium angustum*, *Thelypteris spinulosa* and var. *intermedia*, *Thelypteris Dryopteris*, *Pyrola secunda*, *Linnaea americana*, *Aralia nudicaulis*, *Mitchella repens*, and *Chimaphila umbellata* var. *cisatlantica*. The spurred gentian (*Halenia deflexa*) and also *Gentiana quinquefolia* were noticed in woodland clearings on Garden Island.

In the northern half of Big Beaver there is a comparatively large area of level sandy land broken up by scattered marshes and woods. This lies back of the sand dunes and occupies several square miles.

Over parts of the region the soil becomes dry during the warm season and supports a more or less xerophytic group of woody plants, such as *Prunus pennsylvanica, Shepherdia canadensis, Diervilla Lonicera,* and *Salix humilis.* Open woodland communities here are quite dry by September, but the presence of several species characteristic of mesophytic woodlands, such as *Hepatica triloba, Maianthemum canadense,* and *Trientalis borealis,* indicates considerable moisture in the spring or the early summer. With the drying out of the soil during the late summer and early fall conditions become more favorable to another group, comprising *Gaultheria procumbens, Arctostaphylos Uva-ursi* var. *coactilis, Melampyrum lineare, Campanula rotundifolia, Anaphalis margaritacea, Solidago juncea, Aster macrophyllus,* and *Aster laevis.* Where the ground has been originally cleared or burned over secondary successions (subseres) are coming in. Here the plant communities include *Vaccinium pennsylvanicum, Rubus alleghenien-sis, Rubus idaeus* var. *strigosus,* and *Rubus canadensis.* Typical of the more level areas are *Pteridium latiusculum, Potentilla argentea, Krigia virginica, Apocynum androsaemifolium, Aralia spinosa, Litho-spermum canescens, Monarda fistulosa, Satureja vulgaris, Hieracium paniculatum, Gnaphalium decurrens,* and *Selaginella rupestris,* the last of which forms dense mats in places.

Plants representative of northern bogs are found in the wet soil bordering inland lakes and marshes. The total number of species is comparatively large. Woody vegetation includes two common trees, *Larix laricina* and *Fraxinus nigra,* and the following shrubs: *Chamae-daphne calyculata, Ledum groenlandicum, Betula pumila, Andromeda glaucophylla, Kalmia polifolia, Myrica Gale, Rosa palustris, Cornus stolonifera, Aronia melanocarpa, Vaccinium canadense, Potentilla fru-ticosa, Ilex verticillata, Alnus incana, Viburnum cassinoides, Salix lucida, Salix discolor, Salix candida,* and *Salix pedicellaris.* A thor-ough survey of the herbaceous vegetation could not be made in the limited time at the disposal of the writer. The following list reflects more or less the time of year the observations were made: *Eupa-torium maculatum, Aster puniceus, Bidens laevis, Solidago canadensis, Chelone glabra, Agalinis paupercula, Lysimachia terrestris, Potentilla palustris, Menyanthes trifoliata, Scutellaria epilobiifolia, Scutellaria lateriflora, Hypericum virginicum, Lycopus uniflorus, Lobelia Kalmii, Geum strictum, Impatiens biflora, Viola lanceolata, Iris versicolor, Zygadenus chloranthus,* and *Carex Oederi* var. *pumila*; also the

aquatics, *Pontederia cordata*, *Nymphaea tuberosa*, *Eriocaulon septangulare*, and *Scirpus americanus*; and the fernworts, *Thelypteris palustris*, *Osmunda Claytoniana*, *Osmunda regalis* var. *spectabilis*, *Pteretis nodulosa* (ostrich fern), and *Onoclea sensibilis*. Around the border of Egg Lake there is a typical sphagnum bog girdled by a floating mat, in which were noticed such characteristic plants as *Sarracenia purpurea*, *Drosera intermedia*, *Triglochin palustris*, *Rynchospora alba*, *Rynchospora capillacea*, and *Eriophorum virginicum*.

Considerable areas of peaty soil are occupied by "cedar swamps." Small individuals of white cedar (*Thuja occidentalis*) often stand so thick as to form an almost impenetrable barrier. Where windfalls occur, the characteristic species are *Clintonia borealis*, *Cornus canadensis*, *Mitella nuda*, *Coptis groenlandica*, *Galium triflorum*, and *Chiogenes hispidula*.

The composition of the beach flora varies considerably, depending on the location. The character of the vegetation associated with the dunes paralleling the west shore has been well described by Fuller.[4] Besides *Agropyron dasystachyum*, mentioned by Fuller, *Elymus canadensis* and *Calamovilfa longifolia* occurred here and there sporadically. The two characteristic willows are *Salix adenophylla* and *Salix glaucophylla*, which are common along nearly all sandy shores of the Great Lakes. The surface of the beach ranges from fine sand to coarse gravel or shingle. Two of the interesting species seen in these gravels were the red anemone (*Anemone Hudsoniana*) and *Gentiana procera*, which occasionally formed striking patches of blue. The beach was also white here and there with "grass of Parnassus" (*Parnassia caroliniana*).

As already mentioned, a considerable number of introduced plants occur along roadsides and around settlements. Considering the fact that certain sections have been farmed for many years, one would expect to find some of the commoner grass and forage plants. Among those listed as weeds along roadsides were *Phleum pratense*, *Poa compressa*, *Poa pratensis*, *Melilotus alba*, and *Trifolium repens*. Such plants as *Sedum acre*, *Nepeta Cataria*, *Inula Helenium*, and *Rosa Eglanteria* have probably escaped from gardens. The majority of introductions, totaling at least sixty species, would be classed as weeds. Of these, the most serious from the agriculturist's viewpoint

[4] Fuller, G. D., "Some Perched Dunes of Northern Lake Michigan and Their Vegetation," *Trans. Illinois Acad. Sci.*, 11 : 111–122. 1918.

would undoubtedly be *Agropyron repens, Daucus Carota, Cirsium arvense, Cirsium lanceolatum, Arctium minus,* and *Chrysanthemum Leucanthemum* (probably the variety *pinnatifidum*). Poison ivy (*Rhus Toxicodendron*) was seen growing in and along the borders of woods. Water hemlock (*Cicuta bulbifera*) and water parsnip (*Sium suave*), both of which may poison cattle, occur in low wet ground.

So far as the writer knows, the present paper is the first to outline the vegetational features of Beaver Island as they relate to the vascular plants. Altogether, a total of 333 species was listed. This includes a few from Garden Island. None of the other islands was visited.

In closing, the writer wishes to acknowledge his indebtedness to Mr. L. R. A. Schoenmann and Miss Helen Martin for certain information in regard to geological and physiographic features, and to express his appreciation to members of the Land Division of the Department of Conservation for the use of facilities in the construction of a map of the Beaver Islands.

Michigan State College
East Lansing, Michigan

PLATES I-III

FIG. 1. Fox Lake, in Sec. 28, T. 38 N., R. 10 W. (see map, Fig. 1). The tree in the foreground is white pine (*Pinus Strobus*)

FIG. 2. View from Mount Pisgah, looking northwest, showing High Island in the distance. The open stretch to the right represents the approximate level of glacial Lake Nipissing. The poplars in the foreground indicate the light character of the soil

A part of the sand-dune region northwest of Faunt Lake. Note clumps of low juniper (*Juniperus communis* var. *depressa*) on the left (see text, p. 33)

FIG. 1. Part of the inner shore of Beaver Harbor. The soil here is a sandy loam; the dominant trees are white pine, red pine, and red oak

FIG. 2. The King's Highway, looking south in the vicinity of St. James (see text, p. 32)

ADDITIONS TO THE FLORA OF MICHIGAN. II

CLARENCE R. HANES

THE reports in the first section of this paper are based upon collections by Dr. F. J. Hermann and represent additions to the flora of Washtenaw County. Those in the second part record species hitherto unknown from Kalamazoo County. They are recent collections and were made by Mrs. Florence N. Hanes and the writer unless otherwise stated. Specimens of all the plants have been deposited in the Herbarium of the University of Michigan or in the Gray Herbarium or in the National Herbarium, and duplicates have been incorporated in the collectors' herbaria.

Species marked with an asterisk are new to Michigan, so far as can be determined.

List of Species

WASHTENAW COUNTY

Festuca rubra L. — Gravelly roadside, Arlington Boulevard, Sec. 34, Ann Arbor Township, two and one-half miles southeast of Ann Arbor, May 17, 1938, *F. J. Hermann, 9424.*

Poa languida Hitchc. — Rare, in open oak woods, Sec. 13, Pittsfield Township, five and one-quarter miles southeast of Ann Arbor, May 12, 1938, *F. J. Hermann, 9411.*

Poa paludigena Fern. & Wieg. — Infrequent in Thuja bog, Sec. 31, Dexter Township, two and three-quarter miles northeast of Chelsea, May 30, 1938, *F. J. Hermann, 9463;* frequent on swampy border of Speechley's woods, Sec. 35, Ann Arbor Township, two and three-quarter miles east of Ann Arbor, June 5, 1938, *F. J. Hermann, 9494.*

Panicum Leibergii (Vasey) Scribn. — Gravelly embankment bordering Michigan Central Railroad, Sec. 27, Ann Arbor Township, two and three-quarter miles east of Ann Arbor, June 2, 1938, *F. J. Hermann, 9473.*

The only Michigan record for this species in A. S. Hitchcock

and Agnes Chase's *North American Species of Panicum* (*Contrib. U. S. Nat. Herb.*, 15 : 290. 1910) is "Harsens Island, Lake St. Clair, *Dodge* in 1899."

Walpole's report of *Panicum Ravenellii* from Washtenaw County (*Flora of Washtenaw County* [Ypsilanti, 1924], p. 15) was probably based upon material of this species.

Eleocharis calva Torr. — Extensive beds in marshy field, University of Michigan Botanical Gardens, Ann Arbor, June 20, 1938, *F. J. Hermann, 9501.*

Carex hirsutella Mack. — Plentiful on low grassy edge of abandoned woodland road bordering Mud Lake bog south of Barker Road, Sec. 1, Webster Township, one and three-quarter miles west of Whitmore Lake, June 1, 1938, *F. J. Hermann, 9470.*

Chenopodium leptophyllum Nutt. — Frequent on clay roadside, Huron River Drive, Sec. 35, Ann Arbor Township, three and one-half miles southeast of Ann Arbor, October 6, 1937, *F. J. Hermann, 9380.*

Mitchella repens L. — A small colony in open oak woods, Sec. 13, Pittsfield Township, five and one-quarter miles southeast of Ann Arbor, May 12, 1938, *F. J. Hermann, 9413.*

KALAMAZOO COUNTY AND VICINITY

*Bromus squarrosus L. — Right-of-way of the branch of the New York Central lines, two miles northeast of Schoolcraft, June 9, 1938, *F. W. Rapp, 688.*

The writer collected specimens on June 9, 1938. Mr. Rapp, of Vicksburg, had found it the previous season. Mrs. Agnes Chase, of the National Herbarium, states that there are no reports of this species from the United States. In the second edition of Britton and Brown's *Illustrated Flora of North America* it is given as occurring around Atlantic seaports.

Holcus lanatus L. — Wooded border of swamp near highway in Prairie Ronde Township, four and one-half miles southwest of Schoolcraft, July 11, 1938, *908.*

This grass is given in P. E. Herbert's list of the plants for Berrien County.[1] So far as is known, there are no other records for the state.

[1] "Ferns and Flowering Plants of Berrien County, Michigan," *American Midland Naturalist*, 15 : 325. 1934.

RHYNCHOSPORA FUSCA (L.) Ait. f. — Sphagnum swamp one-fourth mile west of West Lake, Aug. 16, 1938, *2278*.

The only station for Michigan listed in Dr. Beal's "Michigan Flora" [2] is Escanaba.

In Kalamazoo County this plant thrives in a sphagnum bog several acres in extent. Over a large part of the bog it is the dominant species.

*CAREX HOWEI Mack. (*C. scirpoides* var. *capillacea* of *Gray's Manual*, Seventh Edition). — On the south border of Goose Lake, June 12, 1934, *1244;* in Section 32, Prairie Ronde Township, May 29, 1936, *666;* in wooded swamp in Section 34, Schoolcraft Township, June 25, 1938, *1298*.

According to Dr. Hermann these are the only authenticated records for the state.

CAREX UMBELLATA Schkuhr. (*C. umbellata* var. *brevirostris* of *Gray's Manual*, Seventh Edition). — Near the right-of-way of the Grand Trunk Western Railroad three miles east of Schoolcraft, June 4, 1937, *2897*.

It is interesting to note that the only other station for this sedge is on the Keweenaw Peninsula.

*CAREX OLIGOCARPA Schkuhr. — In a maple wood called the "Sugarbush" one-half mile west of the village of Schoolcraft, June, 1933, *1243*.

According to Dr. Hermann, other Michigan collections in herbaria purporting to be *Carex oligocarpa* proved to be *Carex Hitchcockiana* Dewey.

CAREX STRICTA Lam. — Growing in large clumps in a boggy swamp in the northwestern part of St. Joseph County, within a few rods of the Kalamazoo County line, May 7, 1938, *3849*.

Like *Carex umbellata*, this sedge is limited in its Michigan range, having been collected elsewhere only on the Keweenaw Peninsula and on Isle Royale.

*TRADESCANTIA BRACTEATA Small. — In very light sand, northeast of Bradley, Allegan County, June 17, 1938, *Gilbert Becker, 3867*.

Dr. Edgar Anderson, of the Missouri Botanical Garden, has confirmed the determination of this species. The plants were scattered in good-sized patches over more than an acre of ground.

[2] *Annual Rep. Mich. Acad. Sci.*, 5 (1903) : 53. 1904.

It may be adventive or an escape, since this station is distant from its usual range.

*Plagiobothrys hirtus (Greene) Johnston var. figuratus (Piper) Johnston. — On the border of low ground in a field one mile southwest of Schoolcraft, July 27, 1938, *118*.

According to Dr. I. M. Johnston, of the Arnold Arboretum, this is a plant of Oregon and Washington west of the Cascades. The only other report of the species east of the Cascades is from Ludlow, Missouri, 1937.

It is uncertain whether the plant was introduced with alfalfa seed or in stock litter, since the Grand Trunk Western Railroad runs alongside this field.

Schoolcraft, Michigan

RECORDS FOR THE GRAMINEAE OF THE DOUGLAS LAKE REGION, MICHIGAN*

LeROY HATFIELD HARVEY

DURING the summers of 1937 and 1938 the author collected grasses in Cheboygan, Emmet, and Presque Isle counties, Michigan. This collecting and that of Dr. John H. Ehlers over several summers (1932–38) in the same area have resulted in the following additions to the flora of the Douglas Lake region: nine species from Cheboygan County, four from Emmet County, and two from Presque Isle County. Among the number are three species, one from the Lower Peninsula, that seem to be previously unreported from the state.

The author is indebted to Dr. Ehlers for his kind permission to incorporate unpublished records of his in this paper and to Mrs. Agnes Chase and Mr. Jason R. Swallen of the United States National Herbarium for verification of some identifications.

CHEBOYGAN COUNTY

Agrostis palustris Huds.

Found in 1935 by Dr. Ehlers; it was growing on the Cheboygan dump, where it has since maintained itself (Ehlers 5841; Harvey 502, 1937). It was probably introduced there in cuttings from lawns, for it is one of the commonly used lawn grasses.

Bromus tectorum L.

Introduced and spread in Cheboygan County by the railroads. It is now found mostly along the tracks near railroad stations, but is spreading along the roads in the county. Collected at Topinabee in 1937 (Harvey 519).

* Papers from the Department of Botany and Herbarium of the University of Michigan, No. 690.

Calamovilfa longifolia (Hook.) Scribn.

Found sparingly on the dunes of Duncan Bay (Harvey 427, 1937). It was to be expected there, since it occurs along the lake shores on both sides of the county.

Elymus virginicus L.

Locally common in a wet depression in the aspens north of Tower (Harvey 239, 1937). It is found in Emmet County, adjoining, and the habitat is typical, so that the extension is not a surprise.

Eragrostis poaeoides Beauv.

Abundant in 1937 along the Michigan Central Railroad in front of every station in the county. In 1938 it had apparently been completely destroyed by weeding. This is a typical illustration of the distribution of plants by railroads. Collected at Mackinaw City in the railroad yards (Harvey 543).

Festuca octoflora Walt.

Found by Dr. Ehlers in 1934 along a path at the University of Michigan Biological Station at Douglas Lake; it has been slowly spreading since that time (Ehlers 5565; Harvey 600, 1938). It was probably introduced from farther west in mud carried by automobiles.

Lolium temulentum L.

First reported from Michigan by Wright (1839). His specimens are in the University of Michigan Herbarium, but search has failed to show any collection of this species from Michigan by him or by anyone else. The plant occurred in the Cheboygan dump intermixed with clumps of the next species (Harvey 671a, 1938).

Phalaris canariensis L.

Abundant along the swampy edge of the Cheboygan dump in the summer of 1938 (Harvey 671). This as well as the last species may have been introduced in cleanings from cages of canaries, for it yields the canary seed of commerce.

Sporobolus cryptandrus (Torr.) A. Gray

Common in a strip along the Cheboygan–Mackinaw City road (U. S.–23) three to seven miles below Mackinaw City (Harvey 504,

1937). It was probably introduced in straw used to protect fresh concrete from damage by frost when the road was being built or in grass seed sown to bind the shoulder of the road.

EMMET COUNTY

Beckmannia syzigachne (Steud.) Fernald

Found by Dr. Ehlers in the summer of 1932 along the border of a small stream flowing into the Crooked River at Alanson (Ehlers 5112). It has not since been noted there or elsewhere in the area. It may have been a relict of a wider distribution in this state, since it is found in Wisconsin and Illinois. It has not been reported from Michigan before.

Brachyelytrum erectum (Schreb.) Beauv.

Common in moist woods along the Carp Lake River (Harvey 418, 1937). The habitats of this and the two following species were typical and well within their known ranges.

Leersia oryzoides (L.) Swartz.

Common in moist sand along the banks of the Crooked River below Alanson (Harvey 510, 1937).

Panicum tsugetorum Nash

Widespread on old vegetated sand dunes southeast of Sturgeon Bay (Harvey 683, 1938).

Phragmites communis Trin.

An interesting form of this species, found on the flats of Cecil Bay in 1937 (Harvey 492), produces long superficial stolons, which apparently start out as rhizomes but are forced to the surface because of the saturation of the soil. These root at the nodes and bear apparently sterile culms there and at the tips. Stolons forty-three feet long were found at this location. The same form has been seen, but not collected, at Sugar Loaf Lake in Kalamazoo County.

PRESQUE ISLE COUNTY

Muhlenbergia uniflora (Muhl.) Fernald

Collected in 1936 by Dr. Ehlers (6160) along the swampy shores of Lake 16,[1] but not reported from the Lower Peninsula. It was

[1] For a description of this station see Hermann (1936).

found in a typical habitat and well within the known range of the species.

Panicum spretum Schult.

Common along the swampy edge of Lake 16, where it was collected by Dr. Ehlers in 1936 (6161) and by the author in 1938 (665). It is new for Michigan records and is about 450 miles from the nearest known station, on the dunes near Michigan City, Indiana. These two localities are the only ones known in the Middle West; the continuous range is along the Atlantic and Gulf coasts. The discovery adds another typical coastal plain species to the flora of this region.

University of Michigan

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LICHENS OF NORTHERN MICHIGAN *

JOYCE HEDRICK

PRINTED records of northern Michigan lichens are few. In 1925 G. E. Nichols (9) published an extensive list from material collected in the Douglas Lake region in the northern part of the Lower Peninsula. H. T. Darlington in 1931 (3) and 1938 (4) gave the results of his and Dr. Bessey's collecting in the Porcupine Mountains. A few records are to be found in earlier papers by Bogue (1), Dachnowski (2), Fink (5), and Ruthven (10). Some additional ones are in Fink's *Lichen Flora of the United States* (6). A paper on the lichens of Isle Royale by the author and J. L. Lowe (7) and another one by Lowe (8) complete the present knowledge of the lichen flora of the area, which seems to be similar to that of neighboring regions.

The specimens upon which this report is based were gathered by J. L. Lowe during June, 1933, in the region of Munising and Marquette in northern Michigan. Some collections were made by A. H. Smith, who, with Mr. Lowe, was a guest of Dr. and Mrs. E. B. Mains during that time. More than one thousand specimens were obtained. All but those belonging to the family Lecideaceae, which are being studied by Mr. Lowe, are listed here.

The plants were collected in the burns and on the shore-line rocks of Lake Superior. The burns, as the term implies, had been swept by fire and now consist mostly of a scattered growth of aspen and other small trees, and have a rather sparse ground cover. The shore line at Laughing Whitefish Point, Deerton, is low and rocky near the lake, with cliffs rising to 10 and 15 feet farther back, whereas Sugarloaf Mountain, Marquette, rises abruptly to a height of about 500 feet above the water.

The material represents 59 genera in 26 families. The number of genera will be increased when the study of the Lecideaceae is completed. The Isle Royale list gives 60 genera in the same 26 families. Nichols reports 46 genera in 24 families. The present paper consists

* Papers from the Herbarium of the University of Michigan.

of 226 species and subspecies. Nichols gives 155; the Isle Royale publication, 296; and Darlington, 73.

In this paper 15 species and 4 subspecies are reported for the first time in the state, but have been recorded from one or more neighboring regions. For convenience in future study species and subspecies new to the records are starred in the list. The collector's numbers are those of J. L. Lowe unless otherwise stated.

List of Species

VERRUCARIACEAE

*Staurothele umbrina (Ach.) Tuck. — On rock face in gully, Sugarloaf Mountain, Marquette, 2306.

DERMATOCARPACEAE

Dermatocarpon miniatum var. complicatum (Leight.) T. Fries. — On rocks of slope, near Bald Mountain, Big Bay, 2130.

PYRENULACEAE

Leptorhaphis epidermis (Ach.) T. Fries. — On white birch, Rock River, 1796, 2235; on dead birch along shore, Laughing Whitefish Point, Deerton, 1929.

Pyrenula farrea (Ach.) Branth. & Rostr. — On aspen in burn, Rock River, 2205, 2229.

Pyrenula nitida (Weig.) Ach. — On beech between Au Train Lake and Au Train Falls, Au Train, 1555, 1567; on trees along shore, Au Train Lake, Au Train, 2103 (Smith).

CALICIACEAE

Chaenotheca chrysocephala (Turn.) T. Fries. — On hemlock in woods, Onota, 1867; on spruce and cedar in swamp, Laughing Whitefish Point, Deerton, 2525, 2534.

Chaenotheca brunneola (Ach.) Müll. Arg. — On cedar log in woods, Wagner's Falls, Munising, 2033.

Chaenotheca trichialis (Ach.) T. Fries. — On cedar below falls, Wagner's Falls, Munising, 1762; on cedar in bog, Rock River, 1826.

*Calicium lenticulare (Hoffm.) E. Fries. — On conifer stub along shore, Laughing Whitefish Point, Deerton, 1950a.

*Calicium trachelinum Ach. — On cedar, Au Train Lake, Au Train, 2197.

*Calicium pusillum (Ach.) Floerke. — On roots of old stump, Onota, 1859; on under side of stump in woods, Laughing Whitefish Point, Deerton, 2544.

Mycocalicium parietinum (Ach.) Vainio. — On trees and stumps, Au Train Lake, Au Train, 1573, 1579, 2067, 2199, 2200; on cedar in swamp, Rock River, 1830; on conifer stub along shore, Laughing Whitefish Point, Deerton, 1950.

Coniocybe furfuracea (L.) Ach. — On soil and roots of upturned tree, Wagner's Falls, Munising, 1750, 2048; on roots of old tree, Onota, 1857; under rocks in burn and on roots of upturned stump along shore, Laughing Whitefish Point, Deerton, 2497, 2563.

Stenocybe major Nyl. — On balsam in woods, Au Train Lake, Au Train, 2086.

Sprinctrina gelasinata (With.) Zahlbr. — On fallen dead maple between Au Train Lake and Au Train Falls, Au Train, 1577a.

cypheliaceae

Cyphelium tigillare Ach. — On trees along shore and stumps in burn, Laughing Whitefish Point, Deerton, 2483, 2558.

arthoniaceae

Arthonia diffusella Fink. — On cedar along shore, Au Train Lake, Au Train, 2065.

Arthonia radiata (Pers.) Ach. — On basswood bark, Onota, 1860; on alder in swamp, Wagner's Falls, Munising, 2052.

graphidaceae

Opegrapha varia Pers. — On beech, Miner's Falls, Munising, 1666, 1667, 1668; on beech in woods, Chatham, 1620; on maple in woods, Rock River, 1780; on cedar along shore, Au Train Lake, Au Train, 2071; on cedar in swamp, Laughing Whitefish Point, Deerton, 2533.

Opegrapha viridis Pers. — On balsam in woods, Miner's Falls, Munising, 1687.

*Melaspilea arthonioides (Fée) Nyl. — On maple in woods, Rock River, 1782.

Graphis scripta (L.) Ach. — On maple in woods, Onota, 1866; on alder in swamp, Wagner's Falls, Munising, 2050.

Graphis scripta var. recta (Schaer.) Rabenh. — On birch in woods, Miner's Falls, Munising, 1671.

DIPLOSCHISTACEAE

Conotrema urceolatum (Ach.) Tuck. — On hard maple, between Au Train Lake and Au Train Falls, Au Train, 1580; on maple in woods, Rock River, 1779; on branches of fallen tree, Onota, 1871.

Urceolaria scruposa (Schreb.) Ach. — On rocks facing the lake and in gully, Sugarloaf Mountain, Marquette, 2252, 2284.

GYALECTACEAE

Microphiale diluta (Pers.) Zahlbr. — On very moist leaves in woods, Miner's Falls, Munising, 1697.

COLLEMACEAE

*Synechoblastus nigrescens (Huds.) Trev. — On maple log in woods, Chatham, 1605.

*Synechoblastus rupestris (Swartz) Trev. — On trees, Au Train Falls, Au Train, 1585.

Collema furvum (Ach.) DC. — On rocks along shore, Sugarloaf Mountain, Marquette, 2331a.

Collema plicatile Ach. — On rocks along shore, Laughing Whitefish Point, Deerton, 1890, 2444.

Leptogium tremelloides (L.) S. F. Gray. — At base of tree, Au Train, 1553; on rocks along shore, Laughing Whitefish Point, Deerton, 2011; at base of rocks, near Bald Mountain, Big Bay, 2117.

PANNARIACEAE

Parmeliella microphylla (Swartz) Müll. Arg. — On rocks along shore, Laughing Whitefish Point, Deerton, 1992; on soil and rocks, near Bald Mountain, Big Bay, 2121a, 2154.

Pannaria pezizoides (Weber) Trev. — On rocks along shore, Rock River, 2380.

Pannaria leucosticta Tuck. — On rocks, near Bald Mountain, Big Bay, 2121; on rocks in gully, Sugarloaf Mountain, Marquette, 2286; on rocks along shore, Laughing Whitefish Point, Deerton, 2469.

*Pannaria rubiginosa var. conophaea (Pers.) Koerb. — On moss over rocks in gully, Sugarloaf Mountain, Marquette, 2310.

STICTACEAE

Sticta amplissima (Scop.) Rabenh. — On ash in swamp, Au Train, 1554.

Sticta pulmonaria (L.) Bir. — On maple log in woods, Chatham, 1606.

PELTIGERACEAE

Solorina saccata (L.) Ach. — On moss wet by spray, Miner's Falls, Munising, 1674.

Solorina saccata var. spongiosa (J. E. Smith) Nyl. — On moss wet by spray, Miner's Falls, Munising, 1674a.

Nephroma helveticum Ach. — On rock face, near Bald Mountain, Big Bay, 2118.

Nephroma tomentosum (Hoffm.) Flot. — On soil over rocks, near Bald Mountain, Big Bay, 2178a.

Nephroma laevigata Ach. — At base of maple in woods, Onota, 1865; on soil over rocks, near Bald Mountain, Big Bay, 2178.

Nephroma laevigata f. parile (Ach.) Mudd. — On moss over rocks in burn, Laughing Whitefish Point, Deerton, 1971, 2014; on moss on cliff and in gully, Sugarloaf Mountain, Marquette, 2273, 2287.

Peltigera aphthosa (L.) Willd. — On soil with moss, Au Train Falls, Au Train, 1596; on old stump in woods, Wagner's Falls, Munising, 2045.

Peltigera horizontalis (Huds.) Baumg. — On moss-covered log, Au Train Falls, Au Train, 1588; on moss along shore and in woods, Laughing Whitefish Point, Deerton, 1948, 2508.

Peltigera polydactyla (Neck.) Hoffm. — On log near stream, Miner's Falls, Munising, 1689; on moss over rocks in woods, Rock River, 1854; on cliff facing the lake, Sugarloaf Mountain, Marquette, 2275, 2282.

Peltigera scutata (Dicks.) Duby. — On soil over rocks along shore, Laughing Whitefish Point, Deerton, 2000; on cedar along shore, Au Train Lake, Au Train, 2081.

Peltigera malacea (Ach.) Funck. — On soil over rocks along shore, Laughing Whitefish Point, Deerton, 2001; on rocks along shore, Rock River, 2373.

Peltigera rufescens (Weis.) Humb. — On soil over rocks along shore, Laughing Whitefish Point, Deerton, 1927, 1991, 2002; on rocks of cliff facing the lake, Sugarloaf Mountain, Marquette, 2274.

Peltigera rufescens f. sorediata Oliv. — Over moss, Au Train Falls, Au Train, 1587; on rocks facing the lake, Sugarloaf Mountain, Marquette, 2258.

Peltigera praetextata (Sommerf.) Vainio. — On moss over log, Au Train Falls, Au Train, 1588a; on moss along shore, Laughing Whitefish Point, Deerton, 1947; on moss wet by spring in rock face, Sugarloaf Mountain, Marquette, 2294.

Peltigera canina (L.) Willd. — On moss along shore, Laughing Whitefish Point, Deerton, 1946; on moss-covered log in woods, Wagner's Falls, Munising, 2046; on soil over rocks, near Bald Mountain, Big Bay, 2160.

Peltigera spuria (Ach.) DC. — On soil in burn, Laughing Whitefish Point, Deerton, 1932.

lecideaceae

Lecidea granulosa (Hoffm.) Ach. — On old wood on sand bank, Lake Superior shore, west of Au Train, 1642, 1643, 1649, 1655; on sand in burn, Rock River, 1799; on soil in burn, Laughing Whitefish Point, Deerton, 1962.

Mycoblastus sanguinarius (L.) Norm. — On hemlock log, Au Train Falls, Au Train, 1590.

Bacidia inundata (E. Fries) Koerb. — On rocks along shore, Laughing Whitefish Point, Deerton, 2466.

Bacidia luteola (Schrad.) Mudd. — On beech, Chatham, 1621.

Bacidia Schweinitzii (Tuck.) Schneid. — On cedar, Au Train Falls, Au Train, 1581, 1586.

Bacidia suffusa (E. Fries) Schneid. — On ash in woods, Chatham, 1635.

Lopadium pezizoideum (Ach.) Koerb. — On cedar below falls, Wagner's Falls, Munising, 1763.

*Rhizocarpon alboatrum (Hoffm.) Anzi. — On rocks along shore, Laughing Whitefish Point, Deerton, 1937.

*Rhizocarpon grande (Floerke) Arn. — On rocks along shore, Laughing Whitefish Point, Deerton, 1988a; on rocks, near Bald Mountain, Big Bay, 2169, 2172.

*Rhizocarpon lecanorinum (Koerb.) Anders. — On rocks, near Bald Mountain, Big Bay, 2190; on rocks, top of Sugarloaf Mountain, Marquette, 2299.

Rhizocarpon geographicum (L.) Lam. & DC. — On rocks, near Bald Mountain, Big Bay, 2109, 2166, 2190a; on rocks along shore, Sugarloaf Mountain, Marquette, 2335b, 2337.

CLADONIACEAE

Baeomyces rufus (Huds.) Rebent. — On granite rocks in woods, Onota, 1853.

Cladonia rangiferina (L.) Web. — On sand, Lake Superior shore, west of Au Train, 1651.

Cladonia sylvatica (L.) Hoffm. — On sand, Lake Superior shore, west of Au Train, 1650; on moss-covered log, Miner's Falls, Munising, 1696; on fallen birch in woods, Rock River, 1795.

Cladonia alpestris (L.) Rabenh. — On sand ridge, Rock River, 1810; on soil over rocks, near Bald Mountain, Big Bay, 2186.

Cladonia Floerkeana (E. Fries) Sommerf. — On old stump in burn, Rock River, 2221.

Cladonia bacillaris (Del.) Nyl. — On old wood, Lake Superior shore, west of Au Train, 1647; on soil over rocks in burn, Laughing Whitefish Point, Deerton, 1956; on exposed rocks, Sugarloaf Mountain, Marquette, 2238.

*Cladonia macilenta Hoffm. — On sand and old wood, Lake Superior shore, west of Au Train, 1646, 1647a; on old wood in burn, Laughing Whitefish Point, Deerton, 1965; at base of tree, near Bald Mountain, Big Bay, 2148; on soil over rocks, Sugarloaf Mountain, Marquette, 2238a.

Cladonia macilenta var. squamigera Vainio. — On ledge facing the lake, Sugarloaf Mountain, Marquette, 2264.

Cladonia digitata Hoffm. — On old stump in woods and on sand ridge, Rock River, 1770, 1874.

Cladonia coccifera (L.) Willd. — On soil over rocks, near Bald Mountain, Big Bay, 2162; on soil over rocks, Sugarloaf Mountain, Marquette, 2257.

Cladonia coccifera var. pleurota (Floerke) Schaer. — On soil over rocks near shore, Laughing Whitefish Point, Deerton, 1953.

Cladonia deformis (L.) Hoffm. — On sand and old wood, Lake

Superior shore, west of Au Train, 1640; on moist rotten log and sand ridge, Rock River, 1767, 1809.

Cladonia cristatella Tuck. — On soil over rocks near shore, Laughing Whitefish Point, Deerton, 1952.

Cladonia cristatella var. vestita Tuck. — On old log in burn, Wagner's Falls, Munising, 2502.

Cladonia amaurocraea (Floerke) Schaer. — On soil over rocks of cliff, Sugarloaf Mountain, Marquette, 2277; on soil in burn, Rock River, 2223.

Cladonia uncialis (L.) Hoffm. — On sand, Lake Superior shore, west of Au Train, 1654; on soil in burn, Laughing Whitefish Point, Deerton, 1984; on soil over rocks, near Bald Mountain, Big Bay, 2185.

Cladonia furcata (Huds.) Schrad. — On soil over rocks, near Bald Mountain, Big Bay, 2126.

Cladonia furcata f. paradoxa (Vainio) Fink. — On sand ridge, Rock River, 1812, 1842.

Cladonia furcata var. racemosa (Hoffm.) Floerke. — On soil in burn, Rock River, 2225.

Cladonia furcata var. scabriuscula (Del.) Vainio. — On soil over rocks, near Bald Mountain, Big Bay, 2114, 2193.

Cladonia multiformis Merrill. — On old stump in burn, Rock River, 2226.

Cladonia crispata (Ach.) Flot. — On soil on sand ridge and in burn, Rock River, 1847, 2203.

Cladonia crispata var. divulsa (Del.) Arn. — On rotten log, Miner's Falls, Munising, 1704; on sand ridge, Rock River, 1807, 1808.

Cladonia crispata var. infundibulifera (Schrad.) Vainio. — On old wood, Lake Superior shore, west of Au Train, 1641; on soil in burn and along shore, Rock River, 2224, 2374.

Cladonia crispata var. virgata (Ach.) Vainio. — On sand, Lake Superior shore, west of Au Train, 1653.

Cladonia subcrispata Nyl. — On rocks along road, Chatham, 1625; on soil in burn, Laughing Whitefish Point, Deerton, 1973.

Cladonia squamosa (Scop.) Hoffm. — On soil over rocks, near Bald Mountain, Big Bay, 2122, 2156; on soil in burn and on old logs and stumps in woods and along the river, Rock River, 1771, 1801,

2228, 2232; on old log in swamp, Laughing Whitefish Point, Deerton, 2526, 2527.

Cladonia squamosa var. phyllocoma (Rabenh.) Vainio. — On soil over rocks, near Bald Mountain, Big Bay, 2133, 2179; on soil over rocks facing the lake, Sugarloaf Mountain, Marquette, 2255; on stump in woods, Laughing Whitefish Point, Deerton, 2547.

Cladonia squamosa f. squamosissima Floerke. — On old stump in bog, Rock River, 1827.

Cladonia caespiticia (Pers.) Floerke. — On moss over rocks along shore, Rock River, 2386.

Cladonia delicata (Ehrh.) Floerke. — On old log in burn, Rock River, 2220.

Cladonia cenotea (Ach.) Schaer. — On old stump and soil, Rock River, 1772, 1875; on soil over rocks along shore, Laughing Whitefish Point, Deerton, 1961.

Cladonia turgida (Ehrh.) Hoffm. — On sand ridge, Rock River, 1813; on soil over rocks along shore and in woods, Laughing Whitefish Point, Deerton, 1955, 2019; on soil over rocks, near Bald Mountain, Big Bay, 2132.

Cladonia cariosa (Ach.) Spreng. — On soil over rocks along shore and in burn, Laughing Whitefish Point, Deerton, 1910, 2027.

Cladonia decorticata (Floerke) Spreng. — On soil over rocks, near Bald Mountain, Big Bay, 2110, 2163, 2194.

Cladonia gracilis (L.) Willd. — On rotten log in woods, Rock River, 1787.

Cladonia gracilis var. dilatata (Hoffm.) Vainio. — On sand, Lake Superior shore, west of Au Train, 1661 (Smith); on old stump on sand ridge, Rock River, 1846; on old log, Au Train Lake, Au Train, 2399.

Cladonia gracilis var. dilatata f. anthocephala (Floerke) Sandst. — On stump in swamp, Au Train, 1552; on old wood in sand pit along road, Chatham, 1609; on moss-covered log in woods, Miner's Falls, Munising, 1694.

Cladonia cornuta (L.) Schaer. — On sand and on rock ledge along shore and on soil and old stumps in burn, Rock River, 1843, 1852, 2207, 2371, 2394; on stumps on point and on soil over rocks in burn, Laughing Whitefish Point, Deerton, 1876a, 2013a; on rocks facing the lake, Sugarloaf Mountain, Marquette, 2256.

Cladonia cornuta var. phyllotoca (Floerke) Arn. — On sand ridge, Rock River, 1811; on soil over rocks in burn and on humus in woods, Laughing Whitefish Point, Deerton, 1972, 2025.

Cladonia degenerans (Floerke) Spreng. — On soil over rocks, near Bald Mountain, Big Bay, 2116; on rock ledge along shore, Rock River, 2372b.

Cladonia degenerans f. cladomorpha (Ach.) Vainio. — On soil over rocks, near Bald Mountain, Big Bay, 2115.

Cladonia degenerans f. euphorea (Ach.) Floerke. — On rock ledge along shore, Rock River, 2372; on soil in burn, Laughing Whitefish Point, Deerton, 2405.

Cladonia degenerans f. phyllophora (Ehrh.) Floerke. — On soil over rocks, near Bald Mountain, Big Bay, 2112; on soil in burn, Rock River, 2210.

Cladonia degenerans f. polypaea Ach. — On soil in burn, Rock River, 2209.

Cladonia verticillata Hoffm. — In sand pit, Chatham, 1610; on soil over rocks in burn, Laughing Whitefish Point, Deerton, 2016; on soil over rocks, near Bald Mountain, Big Bay, 2113; on rock ledge along shore, Rock River, 2372a.

Cladonia pyxidata (L.) Hoffm. — On moss over rocks in burn, Laughing Whitefish Point, Deerton, 1951.

Cladonia pyxidata var. chlorophaea (Spreng.) Floerke. — At base of tree in woods and on moss-covered log, Miner's Falls, Munising, 1669, 1693; on soil over rocks, near Bald Mountain, Big Bay, 2128; on old log along river, Rock River, 2230; on moss over rocks along shore, Laughing Whitefish Point, Deerton, 2458.

Cladonia pyxidata var. pocillum (Ach.) Flot. — On sand, Lake Superior shore, west of Au Train, 1652.

Cladonia fimbriata var. simplex (Weiss.) Flot. — On soil over rocks in burn, Laughing Whitefish Point, Deerton, 1958; on soil in burn, Rock River, 2395.

Cladonia fimbriata var. cornutoradiata Coem. — On stump on point, Laughing Whitefish Point, Deerton, 1876.

Cladonia fimbriata var. subulata (L.) Vainio. — On soil over rocks along shore and in burn, Laughing Whitefish Point, Deerton, 1911, 2013; on soil over rocks, near Bald Mountain, Big Bay, 2146; on old log along river, Rock River, 2231.

Cladonia fimbriata var. nemoxyma (Ach.) Vainio. — On soil over rocks, near Bald Mountain, Big Bay, 2155.

Cladonia fimbriata var. coniocraea (Floerke) Vainio. — On moss-covered log below falls, Wagner's Falls, Munising, 1756, 1757; on old stump in woods, Rock River, 1768, 1789; on soil over rocks in burn, Laughing Whitefish Point, Deerton, 1957; on soil over rocks, near Bald Mountain, Big Bay, 2182.

*Cladonia fimbriata var. ochrochlora (Floerke) Vainio. — On moss-covered log in woods, Wagner's Falls, Munising, 1764; on old stump in woods, Rock River, 1769, 1793.

Cladonia botrytes (Hag.) Willd. — On pine cone, Lake Superior shore, west of Au Train, 1641 (Smith); on old log and stump in burn, Rock River, 1797, 2227; on old wood and bark, near Bald Mountain, Big Bay, 2103, 2111; on old wood in burn, Laughing Whitefish Point, Deerton, 2028; on soil on ledge, Sugarloaf Mountain, Marquette, 2512.

Stereocaulon paschale (L.) Hoffm. — On soil in burn, Laughing Whitefish Point, Deerton, 2029; on rocks, near Bald Mountain, Big Bay, 2125, 2183, 2184.

Stereocaulon tomentosum E. Fries. — On rock along roadside, Chatham, 1624; on rock in burn, Laughing Whitefish Point, Deerton, 1964.

GYROPHORACEAE

Gyrophora hyperborea Ach. — On exposed rocks, Miner's Castle, Munising, 1733; on rocks along shore, Laughing Whitefish Point, Deerton, 1999; on rocks, near Bald Mountain, Big Bay, 2139.

Gyrophora deusta (L.) Ach. — On rocks in gully and along shore, Sugarloaf Mountain, Marquette, 2301a, 2338a.

Gyrophora Mühlenbergii Ach. — On rocks along shore, Laughing Whitefish Point, Deerton, 2017; on rocks, near Bald Mountain, Big Bay, 2158; on exposed rocks, Sugarloaf Mountain, Marquette, 2339 (Smith), 2510.

Gyrophora vellea (L.) Ach. — On exposed rocks, Sugarloaf Mountain, Marquette, 2240a.

Gyrophora Dillenii (Tuck.) Müll. Arg. — On rocks, near Bald Mountain, Big Bay, 2159; on exposed rocks, Sugarloaf Mountain, Marquette, 2240, 2338 (Smith).

*Umbilicaria pustulata (L.) Hoffm. — On rocks, near Bald Mountain, Big Bay, 2176.

ACAROSPORACEAE

*Acarospora cervina (Ach.) Mass. — On rocks, Laughing Whitefish Point, Deerton, 1892, 2447, 2493; on rocks facing the lake, Sugarloaf Mountain, Marquette, 2245, 2335a.

*Acarospora fuscata (Schrad.) Arn. — On exposed rocks, Miner's Castle, Munising, 1719; on rocks along shore and in burn, Laughing Whitefish Point, Deerton, 1986, 2005, 2008, 2012, 2556; on rocks, near Bald Mountain, Big Bay, 2142, 2173, 2192; on rocks, Sugarloaf Mountain, Marquette, 2246, 2290, 2325, 2335.

Acarospora glaucocarpa (Ach.) Koerb. — On rocks along shore, Sugarloaf Mountain, Marquette, 2320, 2328; on rocks along shore, Laughing Whitefish Point, Deerton, 2434.

PERTUSARIACEAE

Pertusaria multipuncta (Turn.) Nyl. — On ash in woods, Chatham, 1636; on beech, Au Train, 1566; on old log in woods, Wagner's Falls, Munising, 2032; on cedar in swamp, Laughing Whitefish Point, Deerton, 2536.

Pertusaria velata (Turn.) Nyl. — On ash in woods, Chatham, 1637; on aspen on sand ridge and rocks along lake shore, Rock River, 1838, 1844, 2387, 2388; on rocks along shore and on maple in woods, Laughing Whitefish Point, Deerton, 1995, 2015, 2475; on sandstone in woods, Onota, 1858.

Pertusaria leioplaca (Ach.) Lam. & DC. — On living maple, Au Train, 1558, 1561; on birch, Miner's Falls, Munising, 1672; on maple in gully, Sugarloaf Mountain, Marquette, 2291.

Pertusaria pertusa (L.) Tuck. — On fallen dead maple, Au Train, 1577; on cedar and maple along shore, Au Train Lake, Au Train, 2073, 2361.

LECANORACEAE

Lecanora cinerea (L.) Röhling. — On rocks, Miner's Castle, Munising, 1712, 1720; on rocks along shore and in burn, Laughing Whitefish Point, Deerton, 1906, 1980, 2503; on rocks, near Bald Mountain, Big Bay, 2124, 2171, 2181; on rocks in gully, Sugarloaf Mountain, Marquette, 2298, 2312, 2317.

Lecanora laevata (Ach.) Nyl. — On rocks of sheltered cliff facing the lake, Sugarloaf Mountain, Marquette, 2285.

Lecanora subfusca (L.) Ach. — On balsam along shore, Au Train Lake, Au Train, 2088.

Lecanora subfusca var. allophana Ach. — On hemlock branches in woods, Chatham, 1614; on dead birch in swamp, Rock River, 1805; on bark of white pine, near Bald Mountain, Big Bay, 2106.

Lecanora subfusca var. argentata Ach. — On dead maple, Au Train, 1556, 1570; on beech and ash in woods, Chatham, 1619, 1623, 1634; on hemlock in woods and aspen on sand ridge and in burn, Rock River, 1791, 1834, 2212; on balsam in woods, Au Train Lake, Au Train, 2082; on aspen near the lake, Sugarloaf Mountain, Marquette, 2270.

*Lecanora subfusca var. campestris Rabenh. — On rocks along shore, Laughing Whitefish Point, Deerton, 1994, 1996, 2020; on rocks, near Bald Mountain, Big Bay, 2174; on rocks facing the lake, Sugarloaf Mountain, Marquette, 2250.

Lecanora subfusca var. chlarona Ach. — On tree in woods, Wagner's Falls, Munising, 2044.

Lecanora Hageni Ach. — On stump on point and on twigs along shore, Laughing Whitefish Point, Deerton, 1877, 1917.

Lecanora pallida (Schreb.) Rabenh. — On maple in woods, Rock River, 1777; on trees along shore, Au Train Lake, Au Train, 2101.

Lecanora pallida var. cancriformis (Hoffm.) Tuck. — On maple in swamp, Laughing Whitefish Point, Deerton, 2522.

Lecanora varia (Hoffm.) Ach. — On rocks along shore, near Rock River, 2392; on rocks along shore, Laughing Whitefish Point, Deerton, 2421, 2423.

Lecanora polytropa (Ehrh.) Rabenh. — On rocks along shore, Sugarloaf Mountain, Marquette, 2329.

Lecanora frustulosa (Dicks.) Ach. — On rocks along shore, Laughing Whitefish Point, Deerton, 1905, 2491; on rocks, near Bald Mountain, Big Bay, 2140, 2157, 2167, 2170.

Lecanora sordida (Pers.) T. Fries. — On rocks in gully and along shore, Sugarloaf Mountain, Marquette, 2243, 2303, 2321.

Lecanora muralis var. saxicola (Poll.) Tuck. — On rocks along shore, Laughing Whitefish Point, Deerton, 2009, 2454.

Lecanora versicolor (Pers.) Ach. — On rocks along shore, Laughing Whitefish Point, Deerton, 1940, 2448, 2449.

Lecanora rubina (Vill.) Ach. — On exposed rocks, Miner's Falls,

Munising, 1725; on rocks in gully and along shore, Sugarloaf Mountain, Marquette, 2302; 2330 (Smith).

Ochrolechia tartarea (L.) Mass. — On maple in woods, Onota, 1870; on trees, Au Train Lake, Au Train, 2196.

Ochrolechia pallescens (L.) Mass. — On ash in woods, Chatham, 1627; on cedar along shore, Au Train Lake, Au Train, 2057, 2094.

Icmadophila ericetorum (L.) Zahlbr. — On soil over rocks along lake shore, Miner's Castle, Munising, 1730; on old stumps in woods, Rock River, 1773; on old log in swamp, Laughing Whitefish Point, Deerton, 2528.

Lecania erysibe (Ach.) Mudd. — On rocks, Laughing Whitefish Point, Deerton, 1889.

*Haematomma elatinum var. ochrophaeum (Tuck.) Merrill & Burnh. — On cedar along shore, Au Train Lake, Au Train, 2347; on cedar in swamp, Laughing Whitefish Point, Deerton, 2513.

Haematomma cismonicum Belts. — On pine in woods, Laughing Whitefish Point, Deerton, 2518.

Candelariella vitellina (Ehrh.) Müll. Arg. — On rocks along shore, Laughing Whitefish Point, Deerton, 1912, 2496; on rocks along shore, Sugarloaf Mountain, Marquette, 2334.

Candelariella aurella (Hoffm.) Zahlbr. — On rocks along shore, Laughing Whitefish Point, Deerton, 1988, 2460; on rocks along shore, Sugarloaf Mountain, Marquette, 2323.

parmeliaceae

Candelaria concolor var. effusa (Tuck.) Merrill & Burnh. — On old tree along river, Rock River, 2233.

Parmeliopsis aleurites (Ach.) Nyl. — On conifer stump, Lake Superior shore, west of Au Train, 1659; on old stub and logs along shore, Au Train Lake, Au Train, 2093, 2350; on white pine, near Bald Mountain, Big Bay, 2107.

Parmeliopsis ambigua (Wulf.) Nyl. — On conifer stump, Lake Superior shore, west of Au Train, 1660; on decorticate log on ground, Miner's Falls, Munising, 1701; on rocks along shore and in burn, Laughing Whitefish Point, Deerton, 1913, 2022; on trees in burn, Rock River, 2218.

Parmeliopsis diffusa (Weber) Riddle. — On decorticate log in ground, Miner's Falls, Munising, 1700; on old wood in burn, Rock River, 2219.

Parmelia rudecta Ach. — On down hemlock in woods, Chatham, 1613; on cedar in swamp, Rock River, 1831; on cedar along shore, Au Train Lake, Au Train, 2096.

Parmelia Borreri Turn. — On tree, Au Train Lake, Au Train, 1592.

Parmelia physodes (L.) Ach. — On living maple, Au Train, 1557; on conifer stump, Lake Superior shore, west of Au Train, 1658; on branches on ground, Wagner's Falls, Munising, 1765.

Parmelia pertusa (Schrank) Schaer. — On trees along shore, Au Train Lake, Au Train, 2091, 2092, 2398.

Parmelia perlata (L.) Ach. — On log, Au Train Falls, Au Train, 1595; on tree, Miner's Falls, Munising, 1698; on cedar along shore, Au Train Lake, Au Train, 2095, 2363; on trees on cliff toward the lake, Sugarloaf Mountain, Marquette, 2283.

Parmelia perlata var. ciliata (Lam. & DC.) Duby. — On cedar along shore, Au Train Lake, Au Train, 2060, 2079, 2080, 2363a, 2364.

Parmelia cetrata Ach. — On cedar along shore, Au Train Lake, Au Train, 2062.

Parmelia saxatilis (L.) Ach. — On trees, Miner's Falls, Munising, 1699; on rocks in burn, Laughing Whitefish Point, Deerton, 1982, 1993.

Parmelia sulcata Tayl. — On aspen in burn, Rock River, 1841.

Parmelia tiliacea (Hoffm.) Ach. — On alders in swamp and maple in woods, Au Train, 1551, 1563.

Parmelia centrifuga (L.) Ach. — On rocks facing the lake, Sugarloaf Mountain, Marquette, 2241.

Parmelia caperata (L.) Ach. — On down hemlock in woods, Chatham, 1612; on moss over rocks along shore, Rock River, 2385.

Parmelia conspersa (Ehrh.) Ach. — On rocks along shore, Laughing Whitefish Point, Deerton, 1992a.

Parmelia aspidota (Ach.) Röhling. — On beech in woods, Chatham, 1611; on trees and twigs in bog, Rock River, 1814, 1817.

Parmelia sorediata (Ach.) Röhling. — On exposed rocks, Miner's Castle, Munising, 1729; on rocks in burn and along shore, Laughing Whitefish Point, Deerton, 1979, 1983, 2007; on rocks, near Bald Mountain, Big Bay, 2177; on rocks in gully, Sugarloaf Mountain, Marquette, 2311.

Parmelia olivacea (L.) Ach. — On aspen in burn, Rock River, 2213.

Cetraria oakesiana Tuck. — On bark of tree, Au Train, 1571; on logs and branches of trees in woods, Rock River, 1774.

Cetraria juniperina var. pinastri (Scop.) Ach. — On maple in woods, Miner's Falls, Munising, 1707; on white pine along shore, Sugarloaf Mountain, Marquette, 2340 (Smith).

Cetraria lacunosa Ach. — On cedar along shore, Au Train Lake, Au Train, 2063; on tree in burn, Laughing Whitefish Point, Deerton, 2566.

Cetraria aurescens Tuck. — On trees along shore, Au Train Lake, Au Train, 2064, 2353.

Cetraria saepincola (Ehrh.) Ach. — On twigs and stems, Lake Superior shore, west of Au Train, 1645; on twigs in bog and swamp, Rock River, 1816; 2511 (Smith).

Cetraria ciliaris Ach. — On larch in swamp, Rock River, 1802; on cedar along shore, Au Train Lake, Au Train, 2097.

Cetraria islandica (L.) Ach. — On soil over rocks along shore, Laughing Whitefish Point, Deerton, 1990; on soil in burn, Rock River, 2208.

USNEACEAE

Evernia prunastri (L.) Ach. — On conifer stump, Lake Superior shore, west of Au Train, 1661.

Alectoria jubata (L.) Ach. — On exposed rocks, Miner's Castle, Munising, 1731; on spruce twigs in bog, Rock River, 1822; on dead spruce in swamp, Laughing Whitefish Point, Deerton, 2514.

Alectoria jubata var. implexa (Hoffm.) Ach. — On dead spruce in swamp, Laughing Whitefish Point, Deerton, 2516.

Alectoria chalybeiformis (L.) Röhling. — On dead spruce in swamp, Laughing Whitefish Point, Deerton, 2515.

Ramalina calicaris (L.) Röhling. — On trees, Rock River, 1837, 1840, 2390; on white pine along shore, Laughing Whitefish Point, Deerton, 1922; on trees along shore, Au Train Lake, Au Train, 2102.

Ramalina pollinaria (Westr.) Ach. — Under rocks in burn, Laughing Whitefish Point, Deerton, 2499.

Ramalina farinacea (L.) Ach. — On hemlock log, Au Train Falls, Au Train, 1591; on exposed rocks, Miner's Castle, Munising, 1734; on rocks along shore, Laughing Whitefish Point, Deerton, 2010; on trees along shore, Au Train Lake, Au Train, 2078, 2352; on rocks along shore, Rock River, 2382.

Usnea florida (L.) Web. — On sticks on ground, Miner's Falls, Munising, 1706a; on spruce twigs in bog, Rock River, 1821.

Usnea hirta (L.) Wigg. — On sticks on ground, Miner's Falls, Munising, 1706; on spruce twigs in bog, Rock River, 1823; on trees along shore, Au Train Lake, Au Train, 2100, 2195; on dead balsam, Laughing Whitefish Point, Deerton, 2415a.

Usnea ceratina (Ach.) Schaer. — On dead spruce in swamp, Laughing Whitefish Point, Deerton, 2523.

Usnea dasypoga (Ach.) Röhling. — On alder and pine in swamp, Laughing Whitefish Point, Deerton, 2402, 2519, 2550.

Usnea dasypoga var. plicata (L.) Cromb. — On spruce along shore, Au Train Lake, Au Train, 2072.

Usnea cavernosa Tuck. — On spruce twigs in bog, Rock River, 1818, 1819, 1820; on trees along shore, Au Train Lake, Au Train, 2099; on trees in swamp and along shore, Laughing Whitefish Point, Deerton, 2400, 2401, 2403, 2414, 2415, 2551, 2552.

CALOPLACACEAE

Caloplaca cinnabarina (Ach.) Zahlbr. — On rocks along shore, Laughing Whitefish Point, Deerton, 2459, 2460a.

*Caloplaca aurantiaca (Lightf.) T. Fries. — On aspen on sand ridge, Rock River, 1833; on rocks in gully, Sugarloaf Mountain, Marquette, 2244, 2289, 2305; on aspen along shore and on rocks along shore and in burn, Laughing Whitefish Point, Deerton, 2453, 2476, 2498.

Caloplaca cerina (Ehrh.) T. Fries. — On aspen, Au Train Falls, Au Train, 1598.

Caloplaca siderítis (Tuck.) Zahlbr. — On rocks along shore, Laughing Whitefish Point, Deerton, 2492.

Caloplaca murorum (Hoffm.) T. Fries. — On rocks along shore, Sugarloaf Mountain, Marquette, 2322, 2327, 2336.

Caloplaca elegans (Link) T. Fries. — On rocks along shore, Laughing Whitefish Point, Deerton, 1987, 1989.

TELOSCHISTACEAE

Teloschistes lychneus (Ach.) Tuck. — On beech, Miner's Falls, Munising, 1663.

Teloschistes polycarpus (Ehrh.) Tuck. — On aspen, Au Train Falls, Au Train, 1597.

BUELLIACEAE

Buellia punctata var. polyspora (Willey) Fink. — On aspen in burn, Rock River, 2216.

Rinodina oreina (Ach.) Mass. — On exposed rocks, Miner's Castle, Munising, 1717; on rocks, near Bald Mountain, Big Bay, 2161, 2191.

PHYSCIACEAE

Pyxine sorediata (Ach.) E. Fries. — On cedar along shore, Au Train Lake, Au Train, 2059, 2357, 2360a.

Physcia teretiuscula (Ach.) Lynge. — On rocks along shore, Laughing Whitefish Point, Deerton, 1914, 2024, 2031, 2470; on rocks, near Bald Mountain, Big Bay, 2127.

Physcia caesia (Hoffm.) Hampe. — On beech, Au Train, 1564.

Physcia virella (Ach.) Flagey. — On aspen log, Au Train Falls, Au Train, 1599a; on maple along road, Onota, 1861; on cedar along shore, Au Train Lake, Au Train, 2058a.

Physcia obscura (Ehrh.) Hampe. — On aspen log, Au Train Falls, Au Train, 1599; on aspen on sand ridge and in burn, Rock River, 1839, 2214a, 2215.

Physcia endochrysea (Hampe) Nyl. — On beech in woods, Miner's Falls, Munising, 1664.

Physcia stellaris (L.) Nyl. — On aspen log, Au Train Falls, Au Train, 1600; on beech in woods, Chatham, 1618; on aspen in burn, Rock River, 2214.

Physcia pulverulenta (Schreb.) Nyl. — On log along trail in woods, Miner's Falls, Munising, 1670; on cedar along shore, Au Train Lake, Au Train, 2354.

Physcia pulverulenta var. leucoleiptes Tuck. — On maple log and ash tree in woods, Chatham, 1607, 1630.

Physcia hispida (Schreb.) Frege. — On white pine along shore, Laughing Whitefish Point, Deerton, 1923.

Physcia lithotea (Ach.) Nyl. — On rocks along shore, Laughing Whitefish Point, Deerton, 1907.

Anaptychia speciosa (Wulf.) Mass. — On ash in woods, Chatham, 1631; on twigs in bog, Rock River, 1873.

Anaptychia hypoleuca (Mühlb.) Mass. — On cedar along shore, Au Train Lake, Au Train, 2058, 2061, 2360.

Anaptychia aquila (Ach.) Mass. — On cedar along shore, Au Train Lake, Au Train, 2058b.

Anaptychia leucomelaena (HBK) Vainio. — On down cedar along shore, Au Train Lake, Au Train, 2356.

LEPRARIACEAE

Amphiloma lanuginosum (Hoffm.) Nyl. — On stump in woods, Laughing Whitefish Point, Deerton, 2548.

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NOTES ON PLANT ECOLOGY OF NORTHERN ONTARIO

LESLIE A. KENOYER

IN AUGUST, 1932, the writer, with a class of eight students, made a botanical tour in northern Ontario, as far northward as the southern tip of James Bay, for the purpose of studying problems of plant distribution. The area investigated has been made accessible by the opening of an automobile highway to Cochrane and the extension of the Temiskaming and Northern Ontario Railway from Cochrane to Moosonee. We traveled by motor cars to Cochrane, thence by train to Moosonee, which is about one hundred and fifty miles north of Cochrane, and from there by motor boat twelve miles farther, to Ship Sands Island, where the Moose River enters James Bay.

The principal studies were made (1) at Gravenhurst, on Lake Muskoka, in the deciduous forest zone; (2) at Martin River Camp, in the Timagami Forest Reserve, a pine-dominated area of the coniferous forest region; and (3) at Cochrane, in a spruce- and fir-dominated northerly area of the coniferous forest region. Approximately four days were spent at each of these localities. Shorter stops were made at New Liskeard, north of Martin River, on Lake Temiskaming; at Swastika, still farther north, an important gold-mining center on the continental divide between the Great Lakes and Hudson Bay; and at Moosonee, near James Bay, in a region dominated by subarctic forest and muskeg.

I. PLANT FORMATIONS

1. Maple–Beech–Hemlock Forest at Lake Muskoka

The region about Lake Muskoka, although largely cut over by the lumbermen, contains areas of good maple beech–hemlock climax forest. A sample count of large trees in a transect of a typical area gave sugar maple 9, beech 3, hemlock 3. The underlying rock is

pre-Cambrian gneiss, crumpled and coarsely banded, with pegmatite or granitic intrusions in the dikes. The hills are of the type known as *roches moutonnées*, carved by glacial erosion from the original rock mass. The uniform level of the higher ones indicates that previous to erosion the region was almost a plain. This contour, numerous rock striations, and the frequent occurrence of sheets of till point to thorough glaciation of the region. In the troughs between hills are many lakes and marshes. Since much of the country has not reached a stage of physiographic development capable of supporting climax forest, conifers and other rock-surface pioneers are abundant. A transect of one of the rocky pioneer areas gives white pine 9, white birch 8, quaking aspen 8, red oak 4. Large-toothed aspen, white oak, red maple, and arbor vitae occur to some extent, the last usually near the lake borders.

The stages in the xerarch succession from rock to forest were found to be as follows:

1. Lichens. — Crustose, foliose, and fruticose types.

2. Mosses. — Notably *Ceratodon purpureum*, occurring as cushions on the rocks, followed by *Polytrichum piliferum*, which appears in the center of each cushion as it enlarges.

3. Ferns and other herbs of rock or crevice. — *Polypodium vulgare, Aspidium marginale, Woodsia ilvensis, Saxifraga virginiensis, Selaginella rupestris, Maianthemum canadense.*

4. Low shrubs. — *Arctostaphylos Uva-ursi, Vaccinium pennsylvanicum, Juniperus communis.*

5. Larger shrub. — *Rhus typhina.*

6. Pioneer trees. — *Pinus Strobus, Quercus alba, Quercus rubra, Thuja occidentalis, Betula alba papyrifera.*

7. Climax trees. — *Acer saccharum, Fagus grandifolia, Tsuga canadensis.*

2. White Pine Forest in Timagami Forest Reserve

In the Timagami Forest Reserve much of the timber along the highway has been cut, but there are still considerable tracts of virgin forest. A transect in one of these gave white pine 16, balsam fir 6, white birch 6. There is but little yellow birch, for this species here reaches its northerly limit. Red pine is conspicuous in places, particularly on the rocky uplands. The climax trees of the Muskoka region are almost absent here, since there is neither beech nor hemlock and but very little sugar maple occurs. The dominant rôle is assumed

by white pine, not by spruce and fir, as in the areas farther north. This pine appears at an early stage in succession and persists to the climax stage. White birches are everywhere obvious, but especially so in the localities from which the pines have been removed by lumbermen. In this region are many bogs, in which black spruce and tamarack are dominant trees. Some of these bogs are on hilltops and slopes. All are carpeted with picturesque Cladoniae and lichens.

3. Transitional Zone

At New Liskeard, on the northern end of Lake Temiskaming, the forest is similar to that of the Timagami region. Innumerable seedlings of elm and red maple, growing on the sand of the lake beach, show that a deciduous forest element is present even so far north. Above New Liskeard lies a broad strip of glacial débris, the southern clay belt, which is being developed agriculturally and contains but little undisturbed forest. At Swastika a pre-Cambrian dome separates the southern from the northern clay belt. This point is about the northernmost limit of the white pines, and a transition to the more northerly fir–spruce forest type is apparent. One striking feature is a stretch of several miles of sandy glacial outwash with an almost pure stand of jack pine. These are large trees, sixty feet tall, a height rather unusual for this species. A transect here taken gives jack pine 23, white birch 3, white pine 2, black spruce 1. The young trees are mainly white birch and black spruce. It is probable that the jack-pine forest represents a subclimax, which would be succeeded in time by white birch, fir, and, possibly, white spruce. The outwash sand and silt are here deposited in annual layers or varves.

4. Fir–Spruce Forest at Cochrane

In the midst of the northern clay belt lies Cochrane, the most northerly city on the improved highway. The surrounding area is a flat glacial moraine on which agricultural developments are beginning. The soil is immature, the greater part of the area being muskeg, a mossy turf covered with bog shrubs, and with black spruce and tamarack in the proportion of about three to one. In places with better drainage young balsam fir is mixed with the older bog trees. In relatively few areas, in the best-drained soil, the vegetation has apparently reached a climax of fir and white spruce, with a fair sprinkling of the deciduous trees — balsam poplar, quaking aspen,

and white birch. Transects taken in this climax forest gave fir 20, black spruce 12, balsam poplar 12, quaking aspen 10, white spruce 9, white birch 6. The black spruce is doubtless a holdover from the bog stage, indicating that the climax has not been fully attained. Along the Abitibi River is considerable arbor vitae, evidently, as is usual for this species, playing the rôle of a pioneer. There is some question whether the deciduous trees mentioned above really belong to the climax stage, although it seems probable that this distinction should be accorded to balsam poplar and white birch at least. The relatively short time that has elapsed since the glacial period and the slowness of soil maturation in this cool climate may, as suggested by Hutchinson,[1] account for the fact that so small a percentage of the land area has reached the climax stage of development.

5. Muskeg at Moosonee

The country at the lower end of James Bay is described on the official vegetation map as relatively treeless muskeg. The railway to Moosonee follows the Abitibi River to its mouth and then runs along the Moose River. So far as could be determined in the full moonlight of the frosty August nights of our journey, spruce is the dominant tree. But as one proceeds northward the spruces gradually become smaller until, in the boundless expanse of muskeg that surrounds the railway station at Moosonee, the mossy turf is sparsely covered with spindly lichen-bedecked black spruce and tamarack not more than ten to fifteen feet in height. In the better-drained areas near the mouth of the Moose River there are many balsam poplars and some firs. This is probably a nearer approach to the climax than is the poorly drained muskeg occupying most of the level area of the James Bay basin. The undershrubs of this river-bank forest are largely species of willow. In newly formed and relatively moist flood plain areas, such as those we explored at Ship Sands Island, where the river enters James Bay, these willows are the most important element in the vegetation. Included among them here are *Salix lucida*, *S. syrticola*, *S. discolor*, and *S. cordata*. Probably over the flat muskeg the fir and balsam poplar would eventually follow black spruce and tamarack, although in this lati-

[1] Hutchinson, A. H., "Limiting Factors in Relation to Specific Ranges of Tolerance of Forest Trees," *Bot. Gaz.*, 66 : 465–493. 1918.

tude, where the subsoil in places does not thaw out completely during the entire summer, any successional change would be very slow.

The number of species of vascular plants tends to decrease with an increase in the degree of latitude, as may be indicated by the fact that approximately equal periods spent in collecting at the three important points resulted in the listing of the following numbers: Muskoka Lake, 205; Martin River, 179; Cochrane, 140.

II. FREQUENCY STUDIES OF FOREST-FLOOR SPECIES

In order to compare the frequency of the smaller shrubs and herbs we used the method of survey suggested by Raunkiaer.[2] By means of a wire measured to the right length to serve as the radius of a circle of the desired size twenty-five sample plots were circumscribed in each association selected for study, and the species occurring on each plot listed. The plots in a given association were spaced an equal number of steps apart. The area of 0.1 square meter, found most suitable by Raunkiaer in his investigations in Europe, is the one usually employed, but in two areas where the forest-floor vegetation was sparse plots of one square meter were used instead. These surveys were made in nineteen typical plant associations selected in the region from Lake Muskoka to Cochrane.

The species found on the sample plots of each association studied were grouped in the order of their frequency. Thus a species occurring on all twenty-five of the plots is rated as 100 per cent frequent, one found on only twenty as 80 per cent frequent, etc. On the average, the species showing a frequency of up to 20 per cent comprise 63 per cent of the entire number listed. Those with a frequency of 20 to 40 per cent follow, with 17 per cent of the number; the 40 to 60 per cent group provide 10 per cent; the 60 to 80 per cent group, 6 per cent; the 80 to 100 per cent group, 4 per cent. These percentages — 63, 17, 10, 6, and 4 — form an approximately hyperbolic curve, and thus conform to the usual pattern of species distribution.

This survey gives data for comparison of the different forest-floor plants of the Ontario flora. In Table I are found in the order of their frequency the ten most abundant species in the nineteen areas surveyed.

[2] Raunkiaer, Christen, "Recherches statistiques sur les formations végétales." *Kl. danske vidensk. Selsk., Biologiske Meddel.*, 1 : 3. Köbenhavn, 1918.

TABLE I

PLANTS MOST FREQUENT IN NINETEEN AREAS

	Average frequency for the 19 areas	*Number of areas on which species occur*
Maianthemum canadense	42	15
Cornus canadensis	34	15
Vaccinium pennsylvanicum	28	12
Aster macrophyllus	21	12
Aralia nudicaulis	19	13
Mitella nuda	18	7
Clintonia borealis	17	11
Linnaea borealis americana	15	12
Rubus triflorus	15	8
Coptis trifolia	13	9

The species showing the ten highest frequencies in each of the three general association types are given in Tables II, III, and IV:

TABLE II

PLANTS MOST FREQUENT IN NINE CLIMAX-ASSOCIATION AREAS
(With average frequencies)

Maianthemum canadense	47
Cornus canadensis	37
Mitella nuda	30
Aster macrophyllus	29
Aralia nudicaulis	27
Clintonia borealis	25
Rubus triflorus	22
Vaccinium pennsylvanicum	20
Coptis trifolia	16
Vaccinium canadense	13

TABLE III

PLANTS MOST FREQUENT IN FIVE XERARCH SUBCLIMAXES
(With average frequencies)

Vaccinium pennsylvanicum	60
Maianthemum canadense	45
Cornus canadensis	32
Gaultheria procumbens	20
Linnaea borealis americana	18
Pteris aquilina	18
Aralia nudicaulis	15
Aster macrophyllus	15
Trientalis americana	14
Vaccinium canadense	13

TABLE IV

PLANTS MOST FREQUENT IN FIVE HYDRARCH SUBCLIMAXES
(With average frequencies)

Chamaedaphne calyculata	36
Carex oligosperma	34
Maianthemum canadense	31
Cornus canadensis	30
Vaccinium oxycoccus	23
Kalmia polifolia	20
Ledum groenlandicum	20
Coptis trifolia	16
Andromeda glaucophylla	16
Mitella nuda	15

From these tables it is apparent that *Maianthemum canadense* and *Cornus canadensis* are the two most frequent plants in the sections of Ontario studied. Since they are among the ten leaders in each of the three association types they grow under a wide range of conditions.

It will be observed that some of the hydrarch dominants decrease early, dropping below tenth place in the climax associations. In many parts of the climax forest some of these, notably Chamaedaphne, Ledum, and Kalmia, may be found, but are infrequent. Others, such as Cornus, Maianthemum, and Mitella, come early and persist until late in successional development. Aster and Aralia appear rather late. As with the hydrarchs, several of the xerarch dominants also drop out or become relatively infrequent before the mesic stage is reached.

Lines between the pioneer and the climax stages are much less sharply drawn than in the more southerly temperate regions. In southern Michigan, for instance, it is probable that none of the ten most frequent species of either the bog or the sand barren would be included among the ten most frequent in the climax forest, whereas in the Ontario study it will be noted that two of the foremost ten of the climax (Table II) are frequent in both xerarch (Table III) and hydrarch (Table IV) pioneer associations, and that five others of the former list are found in one or the other of the last two. In southern Michigan seven or eight of the ten frequent in the Ontario climax forests are virtually restricted to cold bogs. It is evident either that the northern climate has a leveling influence on vegetation or that, as suggested by Hutchinson (*op. cit.*), the soil of the north, owing

to slow decomposition and other chemical change at low temperatures, has not had time to mature sufficiently to enable it to maintain a climax vegetation.

A rough check on the influence of latitude on species distribution is given in Table V, in which the frequencies of several species in eight areas south of the continental divide between the Great Lakes and Hudson Bay are compared with the frequencies of the same species in nine areas north of the divide.

TABLE V

Species Frequency in Relation to Latitude

	Percentage frequency	
	South of divide	*North of divide*
More frequent southward		
Aster macrophyllus	26	10
Aralia nudicaulis	26	10
Clintonia borealis	23	10
Pteris aquilina	15	0
Gaultheria procumbens	14	0
More frequent northward		
Mitella nuda	4.5	34
Rubus triflorus	4.5	27
Linnaea borealis americana	10	21

The students who gathered the data for this paper are Helen Maul, Jean McClave, Hazel Smith, George Hoehne, and Loretta Locher.

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PLANT ASSOCIATIONS IN BARRY, CALHOUN, AND BRANCH COUNTIES, MICHIGAN, AS INTERPRETED FROM THE ORIGINAL SURVEY

LESLIE A. KENOYER

THE purpose of this paper is to extend the analyses, already published (2, 3), in which six counties in the southwestern corner of Michigan (Berrien, Van Buren, Allegan, Cass, St. Joseph, and Kalamazoo) were mapped to show the plant associations existing at the time of the government land survey, 1826 to 1832, and interpreted from the recorded witness trees. This addition embraces Barry, Calhoun, and Branch counties (Fig. 1), which adjoin on the east those previously studied.

Two witness trees near each section corner and two near the midpoint of each section are named by species. Since trees of ecologically associated species formed well-defined groups when recorded on the county map, it is possible to set fairly definite boundary lines to the areas occupied by the various plant associations. These three counties agree with those already mapped in that oak–hickory and beech–maple forest were the prevailing associations. They were entirely devoid of hemlock, and, except for an occasional white pine, were without pine forest. This confirms the earlier conclusion that hemlock and pine in southeastern Michigan were practically restricted, as they are at present, to the vicinity of Lake Michigan. The area included in the present paper had no well-defined grassland tracts, such as were found in St. Joseph, Kalamazoo, Cass, and Berrien counties. There were, however, in Calhoun County eight small areas in which bur oak was almost the only tree. Since bur oak invariably occurred to some extent in the grassland tracts just mentioned, it is probable that there was a grassy undercover in these small patches in Calhoun County.

Although the greater part of the boulder clay plains area indicated

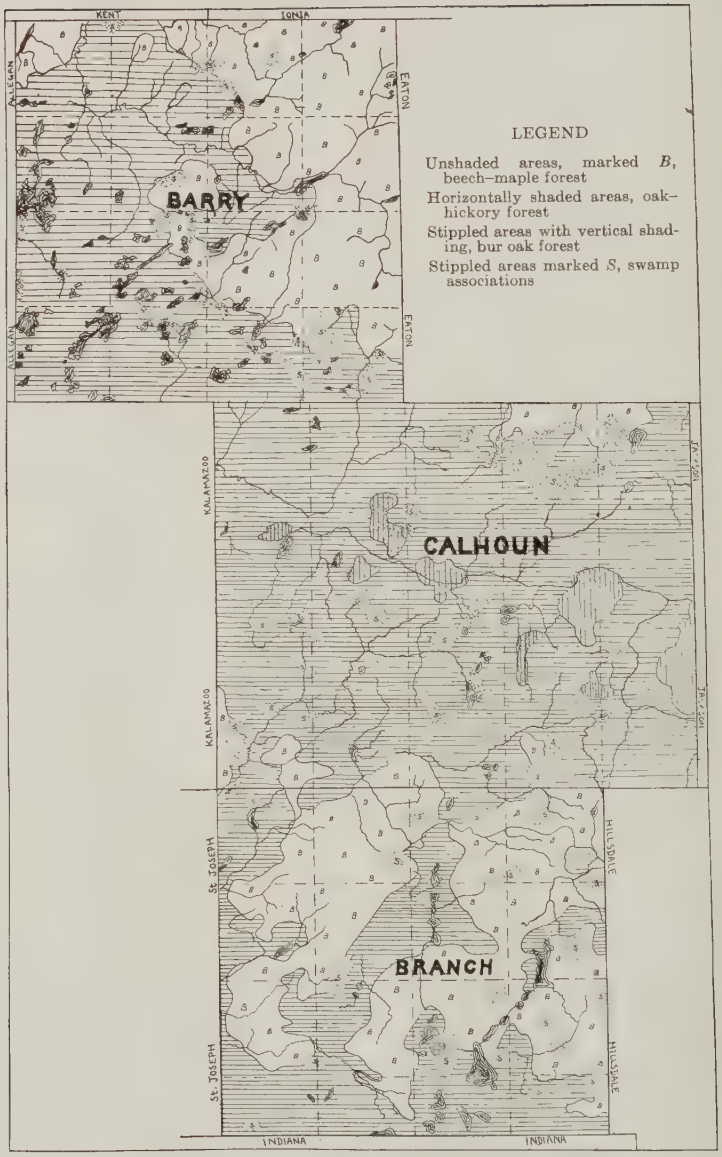

Fig. 1. Plant associations of Barry, Calhoun, and Branch counties

for these counties on Leverett's map (4) was occupied by beech–maple forest, the correlation between beech–maple and boulder clay was at best rather vague. In Barry County, where most of the beech–maple was in a single block, its extent corresponds in a general way with Miami loam on the soil map (1). This finding agrees with that of Veatch (5) from a sample survey comprising portions of five counties of southern Michigan.

It will be observed that Barry County is divided by a roughly diagonal line into a southwestern oak–hickory portion and a northeastern beech–maple portion. The former, as compared with the latter, is poorly drained, with many lakes and few streams. On the other hand, Calhoun County, with three large rivers and few lakes, was almost entirely oak–hickory forest, whereas Branch County, with fewer streams and more lakes than Calhoun, was more than half beech–maple forest. The mapping of other Michigan areas will doubtless throw more light on the factors behind distribution.

Acknowledgment is given the registers of deeds of the three counties for permission to use the field books.

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CORDYCEPS SPECIES FROM MICHIGAN *

EDWIN B. MAINS

NINE species of Cordyceps have been reported for Michigan: *C. clavulata* Schw. (9, 10, 18), *C. formicivora* Schroet. (17), *C. gracilis* (4 as *C. entomorrhiza*, 10), *C. Melolanthae* (Tul.) Sacc. (6 as *C. herculea*, 11), *C. michiganensis* Mains (10), *C. militaris* Link (10, 16, 17, 18), *C. ophioglossoides* Link (10), *C. stylophora* Berk. & Br. (2, 9), and *C. superficialis* (Peck) Sacc. (5). In this paper additional information and records of distribution are given for a number of them. Three species are added, one new, bringing the total for the state to twelve. In 1910 Seaver (20) reported thirteen species for the United States. Several of these have since been shown to be synonymous, and some new ones have been described. The number now recorded for the United States is twenty-one.

Cordyceps ophioglossoides Link

On *Elaphomyces sp.*, Kent Lake, Oakland Co., Aug. 26, 1937, A. H. Smith.

This is a fairly common species in Michigan. It has club-shaped clavae, short-cylindric part spores, and is attached to the subterranean tubers of Elaphomyces by rhizomorphs. In these characters it differs from the following species.

Cordyceps capitata (Holmsk.) Link

On *Elaphomyces sp.*, Kent Lake, Oakland Co., Sept. 19, 1937, A. H. Smith (7610).

This is apparently the first report of the species from Michigan. It doubtless is of more frequent occurrence than the one record would indicate. The clavae are capitate and are seated directly on the tubers; the part spores are slightly fusoid, 34 50 μ long and 4 μ wide.

* Papers from the Department of Botany and the Herbarium of the University of Michigan.

Cordyceps stylophora Berk. & Br.

On larvae of beetles, A. H. Smith, Oakland Co.: Kent Lake, Aug. 26, 1937, and Sept. 13, 1937 (7311, 7554); Horseshoe Lake, Sept. 24, 1937 (7733); Milford, Oct. 24, 1938 (11120).

This is a very interesting species. It has been rarely collected. It was first reported (2) for Michigan from a collection made by G. H. Hicks in 1892 near East Lansing. The type was obtained (1) by Ravenel in South Carolina about 1857. A. H. Smith recently found it in New York and in the Great Smoky Mountains National Park.

The collections listed above are immature, having either undifferentiated asci or asci without differentiated ascospores. This is puzzling because A. H. Smith first observed the clavae of collection 11120 on July 10 and did not collect them until October 24, when spores had not formed. The persistence of the clavae for so long a period is unusual in Cordyceps. Ample opportunity should have been afforded for maturation.

Cordyceps unilateralis (Tul.) Sacc.

Povah (17) reported a specimen of Cordyceps on an ant from Rock River, Alger Co., as *C. formicivora* Schroeter (Pl. I, Fig. 2). Apparently Schroeter's original record (19) of the species from Germany is the only other published report of its occurrence. Petch (15) has recently decided that *C. formicivora* is only a variation of *C. unilateralis*. The clavae of *C. formicivora* were described as capitate, with the perithecia in the terminal heads. *C. unilateralis* has the perithecia in pulvinate stromata located laterally at various places on the clavae (Pl. I, Figs. 1–3). Petch reached his conclusion as a result of a study of collections from the Farlow Herbarium of Harvard University. An examination of these collections has resulted in the same conclusions. The stromata develop at various points on the clavae and occasionally terminally. The species has clavate asci and fusoid ascospores, and Petch (12) has placed it in Ophiocordyceps.

Cordyceps Melolanthae (Tul.) Sacc.

On "June beetle" larvae, Silver Lake, Washtenaw Co., Aug. 5, 1935, A. H. Smith (1718).

Two other collections have been reported (6, 11) from Wash-

tenaw County. Specimens that appear to be of this species have also been received from S. A. Graham. They were collected in the Huron National Forest at the Mack Lake Tower, near Mio, Oscoda County. They are immature, and the clavae are sterile. The species has usually been reported as *C. herculea*, a name which is not tenable (7, 10, 14).

Cordyceps gracilis Mont. & Dur.

On larvae of beetles, Lakeland, Livingston Co., June 4, 1936, A. H. Smith (3966); Ann Arbor, Washtenaw Co., June 12, 1937, A. H. Smith (6375); Sharon Hollow, Washtenaw Co., June 26, 1937, A. H. Smith (6419).

Three other collections have been reported (4, 10) under this name from Wayne, Cheboygan, and Marquette counties. Of these, two are on larvae of beetles and one is on a larva of a lepidopterous insect. Only two other collections have been reported (8) from the United States, one from New York and the other from Indiana.

The Michigan collections (Pl. II, Figs. 1–3) have capitate clavae, which are 3–9 cm. long. The heads are cinnamon-buff to mahogany-red and are punctate from the ostioles. They are globoid to ovoid, 3–6 × 2–4 mm. The stalks are buff, chrome-yellow, or orange-yellow and are 1–2 mm. thick. The perithecia are entirely embedded and are narrow-ovoid or fusoid-ovoid, 720–840 × 240–360 μ. The asci are cylindric, 442–540 × 4–5 μ. The ascospores are filiform and are nearly as long as the asci. They break into part spores which are 6–9 × 1–1.5 μ. Only one of the Michigan specimens on beetle larvae develops from the middle of the larva. The others arise from an end. One specimen has a moderate amount of slender light-colored mycelial strands surrounding the lower part of the stalk. The specimen from lepidopterous larva (Pl. II, Fig. 1) arises from one end and lacks mycelial strands. It does not differ to any appreciable extent from the specimens on beetle larvae.

There has been considerable uncertainty regarding the name which should be applied to this fungus. Until fairly recently most of the specimens have been named *C. entomorrhiza* (Dicks.) Link. In 1913 Lloyd (7) pointed out that *C. entomorrhiza* is the fungus which had been known on the continent of Europe as *C. cinera* and that the species to which the name had generally been given is *C. gracilis*. According to Lloyd and Petch, the collections of Ravenel, upon

which Ellis and Everhart's and Seaver's records (2, 20) of *C. entomorrhiza* are based, are *C. ophioglossoides*. Lloyd reported in 1920 that he had seen only two collections of *C. gracilis* from the United States. In 1934 the writer listed three collections from Michigan.

Recently Petch (13) has questioned the occurrence of *C. gracilis* in America and has concluded that the fungus reported as such is *C. Glaziovii* P. Henn. In his description of *C. Glaziovii* Hennings (3) gives the following information: Clava capitate; the stalk pallid, 6 cm. long, 2–3 mm. thick; the head rufous brown, ovoid-spheroid, 5–7 × 5 mm.; the perithecia immersed, subglobose; the asci cylindric, 120–180 × 4–5 μ; the spores filiform, multiseptate, breaking into numerous segments 0.5 μ thick. The host is doubtfully determined as a larva of a butterfly. Petch (13) states that the host is a larva of a beetle. The Michigan collections show several important points of difference, having narrow-ovoid to fusoid-ovoid perithecia (Pl. II, Fig. 3) and long asci, 442–540 μ.

Petch (13) places considerable emphasis on the following characters, by which he would distinguish *C. gracilis:* presence of free, abundant mycelial strands at the bases of the clavae; development of clavae from the ends of the larvae; and the hosts, lepidopterous larvae. The Michigan fungus occurs on larvae of beetles as well as of lepidopterous insects. The clava usually develops from one end of the larva, but may arise elsewhere. Although free mycelial strands are ordinarily lacking, a moderate development sometimes occurs. These differences hardly justify, however, the exclusion of the Michigan collections from *C. gracilis*.

Cordyceps macularis, comb. nov.

Ophiocordyceps macularis Mains, Proc. Am. Phil. Soc., 74: 269. 1934.

The species was described from a collection made at Harbor Springs, Emmet County. It has been collected in New York also (11). Petch established the genus Ophiocordyceps for the species of Cordyceps having clavate asci and fusoid ascospores which overlap in the asci. Species with these characters do not appear to form a natural group, but are more closely related to species of Cordyceps than to each other.

Cordyceps michiganensis Mains

On larvae of beetles, A. H. Smith: Bass Lake, Washtenaw Co., June 15, 1937 (6306); Milford, Oakland Co., July 29, 1937 (6684).

The species was described (10) in 1934 from collections from Alger and Livingston counties. It has also been collected (11) at Timagami, Ontario, and A. H. Smith recently obtained it in the Great Smoky Mountains National Park. It is a small species, with a number of slender orange clavae growing from the larvae. It is easily overlooked, especially when it is associated with sporophytes of mosses.

Cordyceps paludosa, sp. nov.

Clavis filiformibus, 5.5–13 cm. longis, 0.5–1.0 mm. crassis, griseo-brunneis, terminantibus in acuminatis sterilibus apicibus; peritheciis superficialibus, liberis, lateraliter compressis, ovoideis, 800–855 × 375–410 μ; ascis cylindricis, 480–550 × 8–10 μ; ascosporis filiformibus, 390 490 × 2.0–2.5 μ, multiseptatis, septis 12–18 μ distantibus. (Tab. III, Figg. 1–2.)

In larvis lepidopterarum, Kent Lake, Oakland County, A. H. Smith, Sept. 13, 1937 (7559, specimen typicum); July 28, 1938 (9640).

This species has long, slender filiform clavae, 5.5–13 cm. × 0.5–1.0 mm. They are grayish brown, especially in the lower part, and are covered with a matted felt. They terminate above in long, attenuated acuminate apices. The perithecia are flattened-ovoid and are large, 800 855 × 375–410 μ. The lower portion is grayish brown and the upper is deep brown. They are superficial, free, and often crowded. The asci are cylindric, 480–550 × 8–10 μ. The ascospores are filiform, 390–490 × 2.0–2.5 μ, and are multiseptate, the cells being 12–18 μ long and not readily separating.

This species is related to *C. superficialis* and *C. acicularis*. The former is much smaller, having clavae up to 4.5 cm. long. The perithecia are 360 660 × 300 564 μ, and the asci are 150 270 × 7–9 μ. The ascospores break into segments 14–30 × 1.5–2 μ. *C. superficialis* has been collected on larvae of beetles.

C. acicularis has clavae up to 10 cm. long and 1–2 mm. thick. The perithecia are 360 400 × 270–300 μ; the asci are clavate, 210–

290 × 7–10 μ. The ascospores are slightly fusoid, 160–240 × 2.5–4 μ. They are multiseptate and do not break into segments. *C. acicularis* develops from larvae of beetles.

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Cordyceps unilateralis

FIG. 1. Typical form with pulvinate stromata laterally placed on clava (Farlow Herb. No. 4057). × 5

FIG. 2. The form described as *C. formicivora*, with the stromata terminal (Michigan collection). × 10

FIG. 3. An intermediate form (Farlow Herb. No. 4048). × 10

Cordyceps gracilis

FIG. 1. Capitate clava arising from a lepidopterous larva. × 1.5
FIG. 2. Head showing ostioles of the embedded perithecia. × 10
FIG. 3. Perithecia. × 70

Cordyceps paludosa

FIG. 1. Clava arising from a lepidopterous larva. × 1

FIG. 2. Portion of a clava showing the superficial free perithecia. × 10

NUCLEI IN ACTINOMYCES *

EARL H. NEWCOMER AND GLENN KENKNIGHT

THE genus Actinomyces includes filamentous organisms with a very fine branching mycelium, usually less than a micron in diameter and seldom exceeding 1.5 micra in diameter. Whether or not the mycelium is septate is a matter of considerable disagreement. Reproduction occurs by conidia or by fragmentation spores.

Some investigators classify the Actinomycetes as fungi, others as bacteria, and still others as a distinct group, separate from both fungi and bacteria. They resemble fungi in that they generally produce an abundance of mycelium with true branching, and some species bear aërial conidiophores with conidia in chains. They are of about the same size as bacteria and are like them in that they are usually intolerant of an acid medium. Furthermore, the majority of them take the Gram stain, certain ones are acid-fast, some prefer a reduced oxygen tension, and several species are reported to have been lysed by a bacteriophage (8).

Whether bacteria possess true nuclei is a question that has received considerable attention from many investigators. Although some have reported the presence of discrete nuclei, the nucleus if present is usually considered to be diffuse in nature and not limited by a definite membrane (3, 5). Fungi, on the other hand, possess true nuclei, and this nuclear condition is an important criterion of phylogenetic significance for the separation of fungi from bacteria.

Various workers using cytological stains have reported in the cytoplasm darkly staining bodies which were interpreted by some as nuclei, but by others as metachromatic bodies, ergastic in nature (1, 2, 4). Unfortunately, the lack of specificity of these cytological stains narrowly limits the value of any such observations to purely morphological interpretations.

The Feulgen reaction has long been known and accepted as a

* Journal Article No. 357, N. S., of the Michigan State College Experiment Station.

specific stain for chromatin, and recent improvements in its use as well as the standardization of its constituent basic fuchsin have placed in the hands of workers a highly valuable technique, which is now as reliable as it once was capricious. The authors have used this technique in the course of this study of the nuclear condition in several representatives of the genus Actinomyces.

The organisms were cultured on slides and stained *in situ* by a method devised by Newcomer (6). The medium employed consisted of 1 per cent glucose, 0.05 per cent peptone, 1.2 per cent agar, and 2 per cent gelatin in distilled water. The pH of the medium was adjusted to neutrality with NaOH.

The organisms, after periods of growth of from 3 to 21 days in moist chambers, were killed with Nawaschin's fluid and stained by means of the Feulgen technique, as modified by Tomasi (7). In early preparations much of the aërial mycelium was lost from the slides in the rather rigorous preliminary treatment requisite for the Feulgen reaction. This was subsequently avoided to a large extent by the simple expedient of placing the slides face down in the killing fluid. When several slides are piled one on top of the other, the gentle pressure thus exerted fixes the aërial mycelium firmly to the gelatin fixative. The technique is still susceptible to improvement, however, and further modifications are contemplated.

In the Actinomycetes so prepared and examined discrete intramycelial inclusions of nuclear morphology, which gave a positive reaction to the Feulgen technique and were interpreted as nuclei by the authors, were observed in *Actinomyces viridis* Millard & Burr (a species obtained from the National Type Culture Collection, London, England) and in six isolates of Actinomyces, which are designated by the numbers 2, 4, 7, 30, 35, and 36. Nos. 4 and 30 were isolated from soil (East Lansing, Michigan); Nos. 2, 35, and 36 from Actinomycetes scab lesions on potato tubers (Lake City, Michigan); and No. 7 was taken from a scab lesion on a turnip root (East Lansing).

It is of interest to add that the staining of bodies identical in morphology and position was observed with methylene blue in smears with an albumin fixative, killed with 95 per cent ethyl alcohol and differentiated with 95 per cent alcohol.

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DESMIDS OF ISLE ROYALE, MICHIGAN

THE GENERA STAURASTRUM, MICRASTERIAS, XANTHIDIUM, AND EUASTRUM, WITH A NOTE ON SPINOCLOSTERIUM

GERALD W. PRESCOTT

IN EARLIER papers (7, 8) the author published lists of desmids from Isle Royale, Michigan, together with some critical notes. A review of the literature dealing with Michigan algae indicates that there are no other reports on the desmid flora of the island. The latitude and other edaphic factors do not seem to influence the development of a flora different from that in southerly portions of Michigan from which desmid studies have been made (2, 3, 6, 9, 11). A number of species in the Isle Royale lists are, however, new records for the state.

Several related, or nearly related, genera are included in the present paper, which will be followed by a final report on remaining desmid species in Isle Royale collections. As previously mentioned (7), the samples from which these studies have been made were taken during the biological survey of the island authorized by the Fifty-fifth Legislature of the State of Michigan.

The author wishes to express his appreciation of a grant-in-aid from the American Association for the Advancement of Science. This is being used for the compiling of a desmid iconography, a set of records which is practically indispensable for a satisfactory taxonomic study of these plants. It has already proved to be of great help in the preparation of this and previous papers. The collection of figures, illustrating several thousands of species, is available for lending to students interested in the Desmidiaceae.

Only those species not listed or figured in the author's former papers on Isle Royale desmids are included here, except where critical remarks are called for.

List of Species

STAURASTRUM

Staurastrum is the largest, or nearly the largest, genus in the desmid family. Therefore one might expect it to be represented by more species than appear in the Isle Royale collections. The relatively small number of species and the fewness of the individuals may be accounted for by the manner in which the samples were obtained. According to field notes, no plankton-tow collections were made, and this is borne out by the fact that practically no plankton species of Staurastrum have been found in the samples. The genus lends itself to planktonic habits more easily than do other members of the family except the filamentous forms. The occurrence of certain Staurastrum species in open water, sometimes in great abundance, is made possible by the extension of the cell wall, especially at the angles, into long arms and processes, which of course lend buoyancy to the plant. If plankton samples had been taken no doubt many of the free-floating species, such as those which have been reported from Wisconsin lakes (10), would be found.

Staurastrum alternans De Bréb.; Smith, *Phytoplankton Inland Lakes Wis.*, Part II : 70, Pl. 68, Fig. 4. 1924.

Width 35–36 μ, length 35 μ, isthmus 8.2 μ. Pl. I, Figs. 8–9. Hidden Lake, Scoville Point, Siskowit Outlet Brook.

Staurastrum arachne Ralfs; Smith, *Phytoplankton Inland Lakes Wis.*, Part II : 111, text figure 13. 1924. Forma.

Width 41 μ, length 21 μ, isthmus 7.8 μ. This is another expression of the species, the typical form having been previously recorded (7, Pl. 19, Figs. 13–14). It seems to be nearest var. *curvatum* W. & G. S. West in its proportions, but it is smaller, the arms are shorter, and there is no outward divergence. My specimens are always four-rayed in vertical view and do not have the marginal granules characteristic of the typical form. Pl. III, Figs. 15–16. Moose Lake.

Staurastrum Arctiscon (Ehr.) Lund.; Smith, *Phytoplankton Inland Lakes Wis.*, Part II : 124, Pl. 84, Figs. 1–2. 1924.

Width 118 μ with processes, length 120 μ with processes, isthmus 28 μ. Pl. II, Fig. 1. Moose Lake.

Staurastrum avicula De Bréb.; West and West, and Carter, *British Desmidiaceae*, V : 40, Pl. 133, Figs. 8–10. 1923.

Width 31.2 μ, length 21.4 μ, isthmus 7.8 μ. Pl. I, Fig. 21. Moose Lake, pool at Scoville Point.

STAURASTRUM BRACHIATUM Ralfs; West and West, and Carter, *British Desmidiaceae*, V : 88, Pl. 141, Figs. 14 15; Pl. 142, Figs. 1–7. 1923.

Width 28 μ, length 23.4 μ, isthmus 9 μ. Pl. I, Figs. 13–15. Moose Lake.

STAURASTRUM BREBISSONII Arch.; West and West, and Carter, *British Desmidiaceae*, V : 61, Pl. 137, Figs. 4–5. 1923.

Width 58.5 μ without spines, length 62.4 μ without spines, isthmus 19.5 μ. Except for the smaller size of my specimens they are similar to var. *maximum* Cedercreutz. This plant should be compared with the smaller species *S. pilosum* (Naeg.) Arch. Pl. II, Fig. 4. Damp soil, Passage Island.

STAURASTRUM CAPITULUM var. SPETSBERGENSE (Nordst.) Cooke; West and West, *British Desmidiaceae*, IV : 126, Pl. 118, Fig. 8. 1912.

Width 31.5 μ, length 50.7 μ, isthmus 18 μ. Previously reported (7) but not figured. Pl. II, Figs. 5–7. Dripping cliff, Passage Island.

STAURASTRUM CRENULATUM (Naeg.) Delp.; West and West, and Carter, *British Desmidiaceae*, V : 110, Pl. 143, Figs. 9–13. 1923.

Width 35 μ, length 23.4 μ, isthmus 9.7 μ. Pl. II, Fig. 10. Wallace Lake. Abundant. New record for Michigan.

STAURASTRUM DEJECTUM De Bréb.; Smith, *Phytoplankton Inland Lakes Wis.*, Part II : 73, Pl. 68, Figs. 18–24. 1924.

Width 19.5 μ, length 19 μ without spines, isthmus 5–8 μ. Pl. I, Fig. 18. Hidden Lake.

STAURASTRUM DICKIEI Ralfs; West and West, and Carter, *British Desmidiaceae*, V : 3, Pl. 124, Figs. 14–15. 1923.

Width 62 μ, length 35 μ, isthmus 9.5 μ. Pl. II, Figs. 8–9. Common in Hidden Lake.

STAURASTRUM DICKIEI var. CIRCULARE Turn.; West and West, and Carter, *British Desmidiaceae*, V : 5, Pl. 129, Fig. 16. 1923.

Width 46.8 μ, length 62.6 μ, isthmus 13.6 μ. Pl. II, Figs. 15–16. Moose Lake.

STAURASTRUM DICKIEI var. MAXIMUM W. & G. S. West; Smith, *Phytoplankton Inland Lakes Wis.*, Part II : 76, Pl. 70, Figs. 3 5. 1924.

Width 72 μ, length 45.6 μ, isthmus 11.4 μ. My specimens have less convergent spines than are usually found in this variety. Pl. II, Fig. 17. Moose Lake.

Staurastrum dilatatum var. hibernicum W. & G. S. West, *British Desmidiaceae*, IV : 175, Pl. 136, Fig. 18. 1912.

Width 24 μ, length 22.5 μ, isthmus 7.5 μ. Pl. I, Figs. 16–17. Sphagnum bogs, Scoville Point. New record for Michigan.

Staurastrum furcigerum De Bréb.; West and West, and Carter, *British Desmidiaceae*, V : 188, Pl. 156, Figs. 7–8, 11. 1923.

Width 50 μ with arms, length 54 μ with arms, isthmus 11.7 μ. Pl. III, Figs. 1–2. Hidden Lake, Moose Lake, Wallace Lake.

Staurastrum gladiosum Turn.; West and West, and Carter, *British Desmidiaceae*, V : 57, Pl. 137, Figs. 1–2. 1923.

Width 48.7 μ with spines, 44 μ without spines, length 44.8 μ, isthmus 17.5 μ. Pl. III, Figs. 7–8. Hidden Lake, Moose Lake.

Staurastrum hexacerum (Ehr.) Wittr.; West and West, and Carter, *British Desmidiaceae*, V : 138, Pl. 142, Figs. 11–14. 1923.

Width 35 μ, length 27.3 μ, isthmus 9.7 μ. Pl. II, Figs. 18–19. Siskowit Lake.

Staurastrum iotanum Wolle; West and West, and Carter, *British Desmidiaceae*, V : 121, Pl. 149, Fig. 1. 1923.

Width 15 μ, length 15 μ, isthmus 7μ. Pl. III, Fig. 12. Hidden Lake, Moose Lake. Infrequent in Isle Royale collections.

Staurastrum leptocladum Nordst.; Smith, *Phytoplankton Inland Lakes Wis.*, Part II : 107, Pl. 78, Figs. 1–7. 1924.

Width 74.1 μ, length 39 μ, isthmus 8 μ. Pl. III, Fig. 3. Moose Lake.

Staurastrum leptocladum var. insigne W. & G. S. West; Smith, *Phytoplankton Inland Lakes Wis.*, Part II : 103, Pl. 77, Fig. 15; Pl. 78, Figs. 8–11. 1924.

Width 83.6 μ, length 45.6 μ, isthmus 10.5 μ. My specimens are a little small. Pl. III, Figs. 4–6. Moose Lake. New record for Michigan.

Staurastrum lunatum Ralfs; West and West, and Carter, *British Desmidiaceae*, V : 29, Pl. 133, Figs. 17–19. 1925.

Width 24 μ, length 28 μ, isthmus 8 μ. Pl. II, Figs. 20–21. Bat Island. New record for Michigan.

Staurastrum maamense Arch.; West and West, and Carter, *British Desmidiaceae*, V : 75, Pl. 139, Fig. 10. 1923.

Width 30.4 μ, length 34.2 μ, isthmus 13.2 μ. Reported but not figured (7, p. 208). Pl. III, Fig. 9. Moose Lake.

STAURASTRUM MARGARITACEUM var. ROBUSTUM W. & G. S. West; West and West, and Carter, *British Desmidiaceae*, V : 133, Pl. 150, Fig. 13. 1923.

Width 26.6 μ, length 29.2 μ, isthmus 7.5 μ. Pl. II, Figs 2–3. Hidden Lake. New record for North America.

STAURASTRUM MINNESOTENSE Wolle; Smith, *Phytoplankton Inland Lakes Wis.*, Part II : 81, Pl. 71, Figs. 14–15. 1924.

Width 166–170 μ with spines, length 123.5 μ with spines, isthmus 40.5 μ. This appears to be a ubiquitous species, having been found in subalpine regions of western United States as well as in southern Louisiana, in the bogs of northern United States, and in Canada. Pl. II, Figs. 11–12. Moose Lake.

STAURASTRUM MUTICUM De Bréb.; West and West, *British Desmidiaceae*, IV : 133, Pl. 118, Figs. 16–20. 1912.

Width 35.2 μ, length 37 μ, isthmus 8.5 μ. Pl. IV, Figs. 7–8. Moose Lake.

STAURASTRUM ORBICULARE var. DEPRESSUM Roy et Biss.; West and West, *British Desmidiaceae*, IV : 158, Pl. 124, Figs. 17–19. 1912.

Width 24 μ, length 22.8 μ, isthmus 7.8 μ. Pl. III, Fig. 11. Moose Lake.

STAURASTRUM ORBICULARE var. HIBERNICUM W. & G. S. West, *British Desmidiaceae*, IV : 156, Pl. 124, Figs. 5–9. 1912.

Width 42 μ, length 46.8 μ, isthmus 15.6 μ. Pl. III, Fig. 21. Moose Lake.

STAURASTRUM ORBICULARE var. **truncatum,** var. nov.[1]

Cells much larger than in the type; semicells with broadly rounded basal angles, with upper lateral margins straighter than in the type, and with apex broadly truncate; in vertical view triangular, the angles broadly rounding, sides slightly concave; cell wall smooth. Width 60–63 μ, length 70–74.5 μ, isthmus 17–19.5 μ. Pl. III, Figs. 14, 20. Moose Lake.

STAURASTRUM PACHYRHYNCHUM Nordst.; Taylor, "Fresh-Water

[1] *Staurastrum orbiculare* var. **truncatum,** var. nov. — Cellulae in varietate multo maiores quam in typo; semicellulae angulis inferioribus late rotundatis, marginibus lateralibus superioribus directioribus quam in typo, apice late truncato; de vertice visae triangulares, angulis late rotundatis, lateribus subconcavis; membrana glabra. Lat. 60–63 μ, long. 70–74.5 μ, isth. 17–19.5 μ.

Algae of Newfoundland, Part II," *Pap. Mich. Acad. Sci., Arts, and Letters*, 20 : 195, Pl. 34, Fig. 1. 1935.

Width 32 μ, length 35 μ, isthmus 7.8 μ. Pl. III, Fig. 13. Moose Lake.

STAURASTRUM PARADOXUM var. PARVUM West; West and West, and Carter, *British Desmidiaceae*, V : 106, Pl. 145, Fig. 6. 1923.

Width 24 μ, length 21 μ. Pl. III, Fig. 17. Hidden Lake.

STAURASTRUM PENTACERUM (Wolle) G. M. Smith; Smith, *Phytoplankton Inland Lakes Wis.*, Part II : 112, Pl. 80, Figs. 15–18. 1924. Forma.

Width 87 μ, length 49.4 μ, isthmus 15.2 μ. This plant combines some characteristics of *S. pentacerum* (Wolle) G. M. Smith and *S. Ophiura* Lund. It has the proportions of the latter but the size of the former, and, as in the former, the bases of the semicells are devoid of spines. It seems better to assign it to this species. Pl. IV, Fig. 2. Moose Lake.

STAURASTRUM POLYTRICHUM Perty; West and West, and Carter, *British Desmidiaceae*, V : 53, Pl. 136, Figs. 8–10. 1923.

Width 58.5 μ, length 53 μ, isthmus 17 μ. Common in several collections.

STAURASTRUM PSEUDOSEBALDI Wolle; West and West, and Carter, *British Desmidiaceae*, V : 113, Pl. 166, Fig. 4. 1923. Forma.

Width 57 μ, length 39 μ, isthmus 12 μ. This seems to belong here, but our specimens are smaller than the size usually recorded for the typical expression. Pl. IV, Figs. 3–4. Moose Lake.

STAURASTRUM PUNCTULATUM De Bréb.; West and West, *British Desmidiaceae*, IV : 179, Pl. 127, Figs. 8–11, 13–14. 1912.

Width 21.4 μ, length 21.4 μ, isthmus 11.7 μ. Pl. III, Figs. 18–19. Bat Island.

STAURASTRUM ROTULA Nordst.; Smith, *Phytoplankton Inland Lakes Wis.*, Part II : 116, Pl. 81, Figs. 5–8. 1924.

Width 64.3 μ, length 46.5 μ, isthmus 12 μ. Pl. IV, Figs. 5–6. Moose Lake. New record for Michigan.

STAURASTRUM RUGULOSUM De Bréb.; West and West, *British Desmidiaceae*, IV : 178, Pl. 126, Fig. 3. 1912.

Width 37 μ, length 35 μ. West and West suggest that this is an expression of *S. alternans* De Bréb. and question its validity. Our specimens seem to have much in common with *S. alternans*, and they should be compared. Pl. IV, Fig. 1. Moose Lake.

STAURASTRUM SEXCOSTATUM var. PRODUCTUM West; West and West, and Carter, *British Desmidiaceae*, V : 148, Pl. 150, Fig. 15. 1923.

Width 41.9 μ, length 44 μ, isthmus 17.5 μ. Pl. III, Fig. 22. Soil on Passage Island. New record for Michigan.

STAURASTRUM TETRACERUM Ralfs;. West and West, and Carter, *British Desmidiaceae*, V : 118, Pl. 149, Figs. 2–4. 1923.

Cells very small, width 20–25 μ, length 23–26 μ, isthmus 4 μ. Pl. IV, Fig. 9. Moose Lake.

STAURASTRUM TOHOPEKALIGENSE Wolle; Wolle, *Desmids of the United States*, p. 164, Pl. 47, Figs. 4–5. 1892. Forma.

Width 43.9 μ with arms, length 50.7 μ with arms, isthmus 15.6 μ. My specimens showed another of the numerous variations common to this species. They are somewhat unusual in that the apical processes are fewer (four) than the lateral (six). The reverse situation is the more common arrangement. Pl. II, Figs. 13–14. Moose Lake.

MICRASTERIAS

MICRASTERIAS AMERICANA var. BOLDTII Gutw.; West and West, *British Desmidiaceae*, II : 120, Pl. 53, Fig. 6. 1905.

Width 97.5 μ, length 113.2 μ, isthmus 27.3 μ. Because of the denticulate apices of the lobules the Isle Royale specimens bear a resemblance to var. *Lewisiana* West. Pl. III, Fig. 10. Siskowit Lake.

MICRASTERIAS APICULATA (Ehr.) Menegh.; West and West, *British Desmidiaceae*, II : 97, Pl. 47, Figs. 1–2. 1905.

Width 120.9 μ, length 124.8 μ, isthmus 31.2 μ. Pl. IV, Fig. 14. Hidden Lake.

MICRASTERIAS CRUX-MELITENSIS (Ehr.) Hass.; West and West, *British Desmidiaceae*, II : 116, Pl. 53, Figs. 1–3. 1905.

Width 105 μ, length 117 μ, isthmus 17.5 μ. Pl. IV, Fig. 10. Hidden Lake.

MICRASTERIAS LATICEPS Nordst.; Smith, *Phytoplankton Inland Lakes Wis.*, Part II : 41, Pl. 59, Fig. 3. 1924.

Width 152 μ, length 136.5 μ, isthmus 23.4 μ. Pl. IV, Fig. 17. Hidden Lake.

MICRASTERIAS PAPILLIFERA De Bréb.; West and West, *British Desmidiaceae*, II : 91, Pl. 44, Figs. 1–2, 7. 1905.

Width 113.1 μ, length 117 μ, isthmus 23.4 μ. Pl. IV, Fig. 16. Moose Lake.

MICRASTERIAS PINNATIFIDA (Kuetz.) Ralfs; West and West, *British Desmidiaceae*, II : 80, Pl. 41, Figs. 7–11, 13. 1905.

Width 55–60 μ, length 55–65 μ, isthmus 16 μ. Pl. IV, Fig. 12. Moose Lake.

MICRASTERIAS RADIATA Hass.; Smith, *Phytoplankton Inland Lakes Wis.*, Part II : 50, Pl. 63, Fig. 1. 1924.

Width 136.5 μ, length 156 μ, isthmus 19.5 μ. Pl. IV, Fig. 13. Moose Lake.

MICRASTERIAS ROTATA (Grev.) Ralfs; West and West, *British Desmidiaceae*, II : 102, Pl. 48, Figs. 1–6. 1905.

Width 214.5 μ, length 234 μ, isthmus 33 μ. Moose Lake.

MICRASTERIAS SOL (Ehr.) Kuetz.; West and West, *British Desmidiaceae*, II : 95, Pl. 46, Figs. 1–2. 1905.

Width 138.4 μ, length 148.2 μ, isthmus 11.7 μ. Moose Lake.

XANTHIDIUM

XANTHIDIUM ANTILOPAEUM (De Bréb.) Kuetz.; Smith, *Phytoplankton Inland Lakes Wis.*, Part II : 57, Pl. 65, Figs. 5–6. 1924.

Width 58.5 μ with spines, length 54.6 μ with spines, isthmus 13.6 μ. Moose Lake.

XANTHIDIUM ANTILOPAEUM var. POLYMAZUM Nordst.; Smith, *Phytoplankton Inland Lakes Wis.*, Part II : 58, Pl. 65, Figs. 7–9. 1924.

Width 70.2 μ with spines, length 66.3 μ with spines, isthmus 15.6 μ. Pl. IV, Fig. 15. Moose Lake.

XANTHIDIUM CRISTATUM var. UNCINATUM De Bréb.; Smith, *Phytoplankton Inland Lakes Wis.*, Part II : 60, Pl. 66, Fig. 4. 1924.

Width 41.8 μ without spines, 55 μ with spines; length 57.5 μ without spines, 73.4 μ with spines; isthmus 18 μ. Pl. IV, Fig. 11. Moose Lake.

EUASTRUM

This interesting genus is fairly well represented in Isle Royale collections and includes a number of large and very beautiful species. Of the group nearly all have been listed in a previous account (7). Additions to the list already published and a few forms from the previous report which seem to merit illustration are included here.

Euastrum affine Ralfs; Krieger, *Die Desmidiaceen*, Lief. 3 : 520, Pl. 68, Figs. 2–4. 1937.

This species has a large median mucilage pore. The wall is coarsely scrobiculate at the angles of the cell. Width 62.4 μ, length 117 μ, isthmus 19.5 μ. Pl. I, Fig. 1. Moose Lake.

Euastrum attenuatum var. lithuanicum Krieger, *Die Desmidiaceen*, Lief. 4 : 542, Pl. 73, Figs. 18–19. 1938. Forma.

Width 35.1 μ, length 59.5 μ, thickness 23.4 μ, isthmus 11.7 μ. This interesting form of *E. attenuatum* is characterized by a much broader and stouter apical lobe than that of the typical plant and by basal lobes with a deep lateral emargination. The basal lobes are coarsely granular at the margins, and the apex is beset with heavier folds than appear in the typical form. Pl. I, Figs. 2–4. Hidden Lake. New record for North America.

Euastrum crassum var. scrobiculatum Lund.; Krieger, *Die Desmidiaceen*, Lief. 3 : 512, Pl. 65, Figs. 2–5. 1937.

This species has a large median pore which sometimes is not shown in published figures of the plant. Width 74.2 μ, length 156.4 μ, isthmus 16–24 μ. Pl. I, Fig. 10. Hidden Lake.

Euastrum incrassatum Nordst.; Krieger, *Die Desmidiaceen*, Lief. 4 : 582, Pl. 85, Figs. 16–18. 1938.

Width 25.5 μ, length 39 μ, isthmus 11.4 μ. Our specimens show two basal granules rather than one as in the typical expression. Pl. I, Figs. 5–7. Moose Lake. New record for North America.

Euastrum pectinatum De Bréb.; Krieger, *Die Desmidiaceen*, Lief. 3 : 536, Pl. 72, Figs. 4–7. 1937. Forma.

The nodules on the face of the semicell are comparable to the typical form, but the apical lateral angles are not extended. In side view my specimens show a much thicker cell, with protuberances or swellings on the upper lateral margins and another swelling at the basal lateral margins. There is so much variation and intergrading among the individuals in the Isle Royale collections that new variety names do not seem warranted. Width 48.7 μ, length 66.3 μ, isthmus 9.7 μ. Pl. I, Figs. 11–12. Another form is shown in Pl. I, Fig. 19. Moose Lake.

Euastrum pectinatum var. brachylobum f. rostratum Taylor; Krieger, *Die Desmidiaceen*, Lief. 4 : 539, Pl. 73, Figs. 4–5. 1938.

Width 44.8 μ, length 70 μ, isthmus 12 μ. Pl. I, Fig. 20. Hidden Lake. New record for Michigan.

EUASTRUM PECTINATUM var. **scrobiculatum,** var. nov.[2]

Variety with apical lobe short, the apices convex, and with a deep emargination in the lateral walls of the basal lobes; wall coarsely scrobiculate; two large tuberculations within the margin of the basal lobules; side view subquadrangular, a large median tuberculation on the lateral margins and a smaller one just below it on the basal angles. Width 47–49.4 μ, length 73–76.4 μ, isthmus 15.2 μ. Pl. I, Fig. 22. Moose Lake.

EUASTRUM VENTRICOSUM Lund.; West and West, *British Desmidiaceae*, II : 4, Pl. 33, Figs. 1–3. 1909. Forma.

Width 87.7 μ, length 138.4 μ, isthmus 23.4 μ. The apical lobe in our specimens is more truncate, the upper lateral angles are more produced than in the typical form, and the sinus between the upper and the lateral lobules is more open. Moose Lake.

SPINOCLOSTERIUM

In an earlier paper (7, p. 203) the author described what was considered to be a new genus (Closterioides) in the Desmidiaceae. Since the publication of that paper he has found it to have been previously described by Bernard (1, p. 31, Fig. 35) as Spinoclosterium. The writer has been fortunate in seeing the living plant a number of times in collections taken from bog lakes in northern Wisconsin. The desmid-like features which were not altogether convincing as seen in the preserved specimens in the Isle Royale collections have been definitely confirmed. The terminal vacuoles, for example, were quite clear in the living plants. Dr. C. E. Taft reports by correspondence that he has found this desmid in the Lower Peninsula of Michigan. It appears to be, therefore, a definite species with a wide geographical distribution, and is not, as has been intimated, an aberrant or abnormal form of some other desmid. Whether the plant should be assigned to a section of the genus Closterium is a debatable question. The spiny character of the wall seems to the writer to

[2] *Euastrum pectinatum* var. **scrobiculatum,** var. nov. — Varietas lobo apicali brevi, apicibus convexis, parietibus lateralibus loborum inferiorum profunde emarginatis; pariete crasse scrobiculato; tuberculis duobus magnis intra loborum inferiorum marginem; a latere visa subquadrangularis, tuberculo mediano magno in marginibus lateralibus sito, secundo minore paullo infra hoc posito in angulis inferioribus. Lat. 47–49.4 μ, long. 73–76.4 μ, isthmus 15.2 μ.

be sufficient justification for removal from that genus. The North American specimens are a little stouter (58 62 μ as compared with 47–52 μ) than the specimens described by Bernard (1). Also, in the Michigan plants spines are stouter and longer, and there is a distinct swelling of the apices, which apparently is not true for the Malay specimens. The concretions on the wall may or may not be of significance. They appear on the older half of all the specimens which the author has seen. *Closterioides spinosum* Prescott (7, p. 203, Pl. XIX, Figs. 1–3) is reduced to synonymy as follows: *Spinocloste rium curvatum* var. *spinosum* nob.

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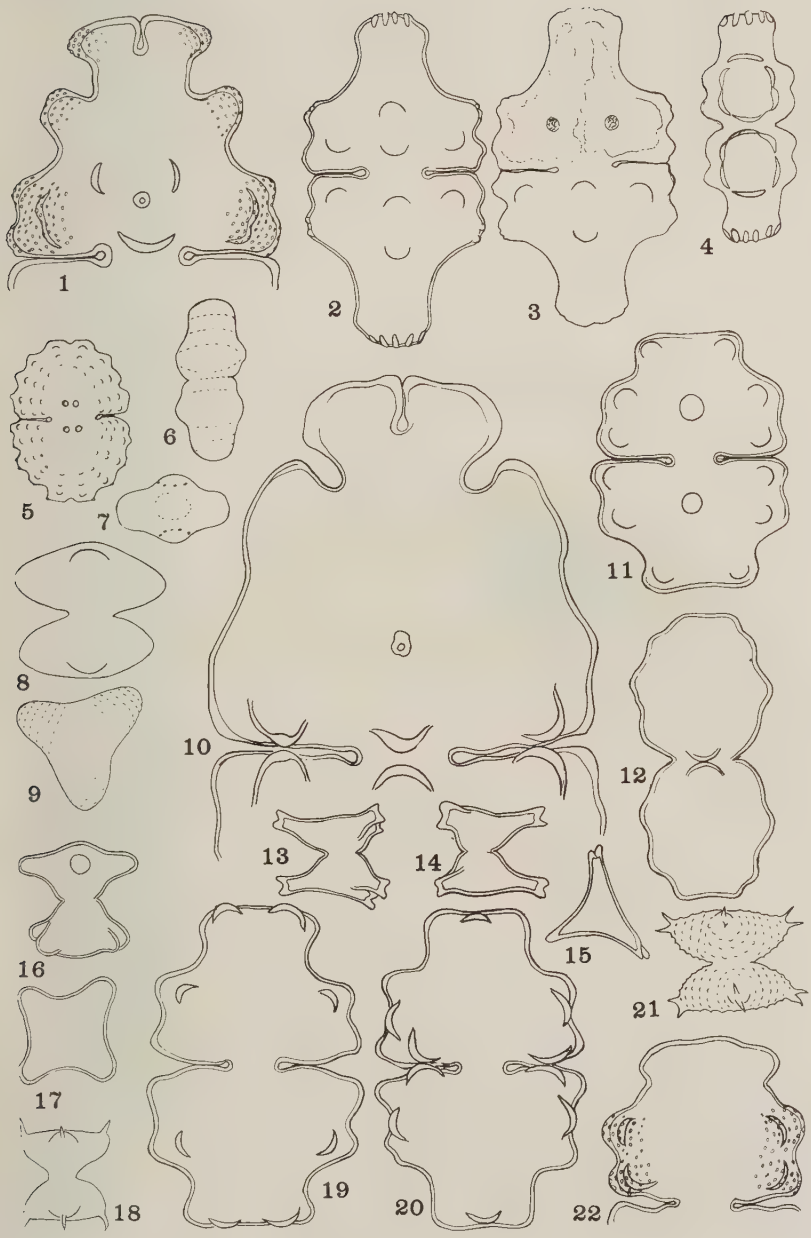
15. Wolle, Rev. Francis. 1892. Desmids of the United States and List of American Pediastrums. Bethlehem, Pa.

EXPLANATION OF PLATE I

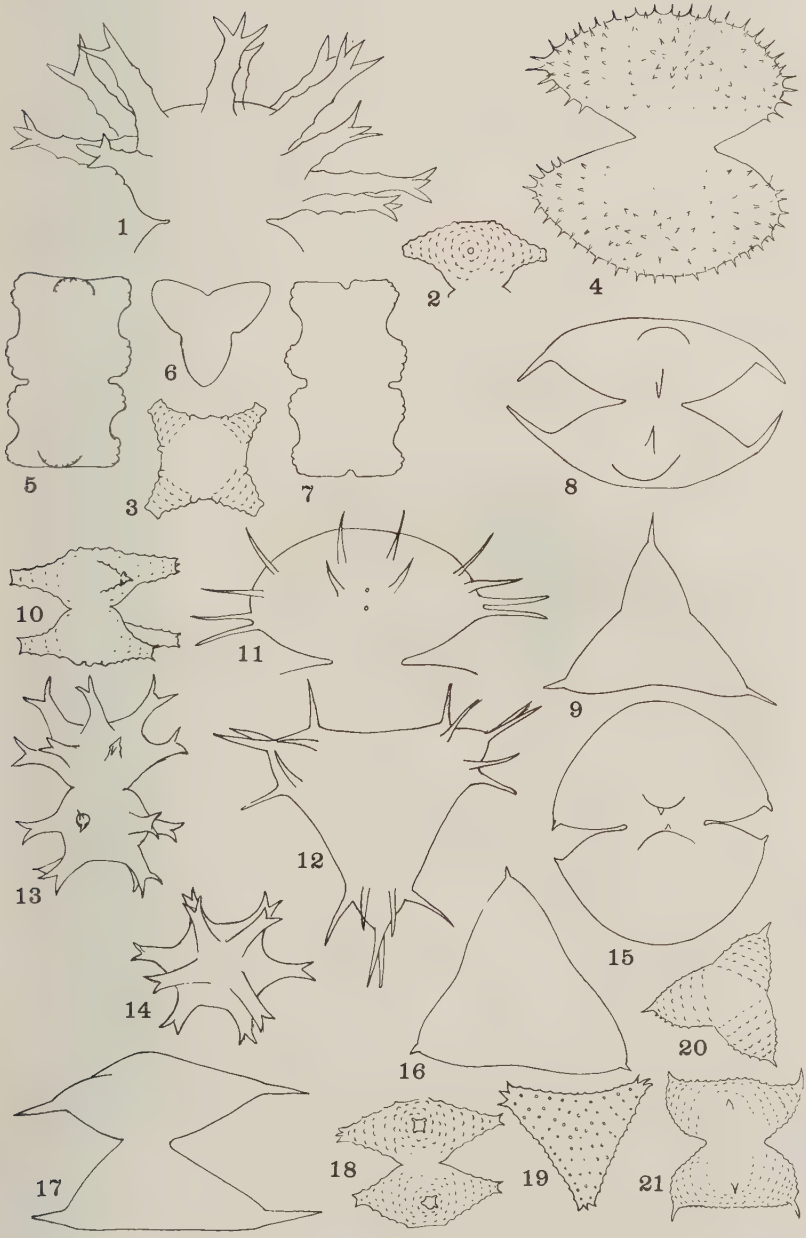
1. Euastrum affine Ralfs. × 440
2–4. E. attenuatum var. lithuanicum Krieger, f. × 600
5–7. E. incrassatum Nordst. × 440. (Fig. 6 after W. & G. S. West)
8–9. Staurastrum alternans De Bréb. × 440
10. Euastrum crassum var. scrobiculatum Lund. × 440
11–12. E. pectinatum De Bréb., f. × 440
13–15. Staurastrum brachiatum Ralfs. × 440
16–17. S. dilatatum var. hibernicum W. & G. S. West. × 600
18. S. dejectum De Bréb. × 480
19. Euastrum pectinatum De Bréb., f. × 440
20. E. pectinatum var. brachylobum f. rostratum Taylor. × 440
21. Staurastrum avicula De Bréb. × 440
22. Euastrum pectinatum var. scrobiculatum, var. nov. × 440



Desmids of Isle Royale

EXPLANATION OF PLATE II

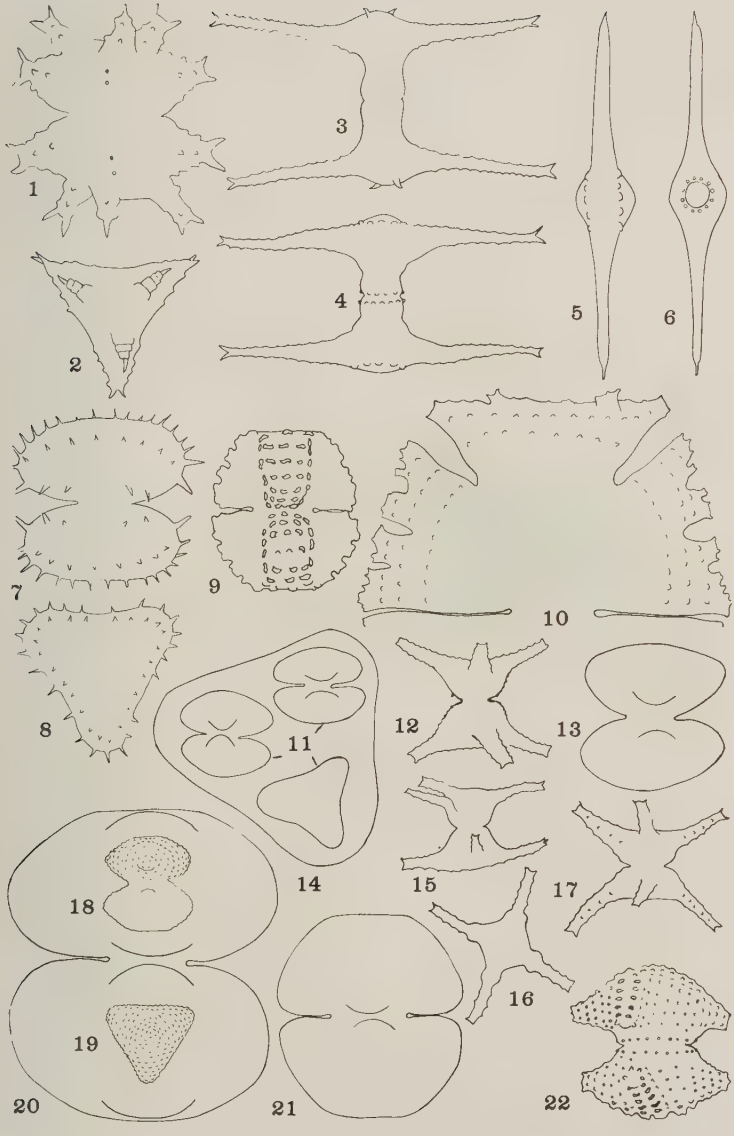
1. Staurastrum Arctiscon (Ehr.) Lund. × 440
2 3. S. margaritaceum var. robustum W. & G. S. West. × 440
4. S. Brebissonii Arch. × 440
5 7. S. Capitulum var. spetsbergense (Nordst.) Cooke. × 440
8 9. S. Dickiei Ralfs. × 482
10. S. crenulatum (Naeg.) Delp. × 440
11–12. S. minnesotense Wolle. × 265
13 14. S. tohopekaligense Wolle, f. × 440
15 16. S. Dickiei var. circulare Turn. × 440
17. S. Dickiei var. maximum W. & G. S. West. × 440
18 19. S. hexacerum (Ehr.) Wittr.; Fig. 18, × 440, Fig. 19 (after W. & G. S. West), × 390
20–21. S. lunatum Ralfs. × 440



Desmids of Isle Royale

EXPLANATION OF PLATE III

1 2. Staurastrum furcigerum De Bréb. × 440
3. S. leptocladum Nordst.. × 440
4 6. S. leptocladum var. insigne W. & G. S. West. × 440
7–8. S. gladiosum Turn. × 440
9. S. maamense Arch. × 440
10. Micrasterias americana var. Boldtii Gutw. × 440
11. Staurastrum orbiculare var. depressum Roy et Biss. × 440
12. S. iotanum Wolle. × 1900
13. S. pachyrhynchum Nordst. × 440
14, 20. S. orbiculare var. truncatum, var. nov. × 440
15-16. S. arachne Ralfs, f. × 440
17. S. paradoxum var. parvum West. × 600
18 19. S. punctulatum De Bréb. × 440
21. S. orbiculare var. hibernicum W. & G. S. West. × 440
22. S. sexcostatum var. productum West. × 440



Desmids of Isle Royale

EXPLANATION OF PLATE IV

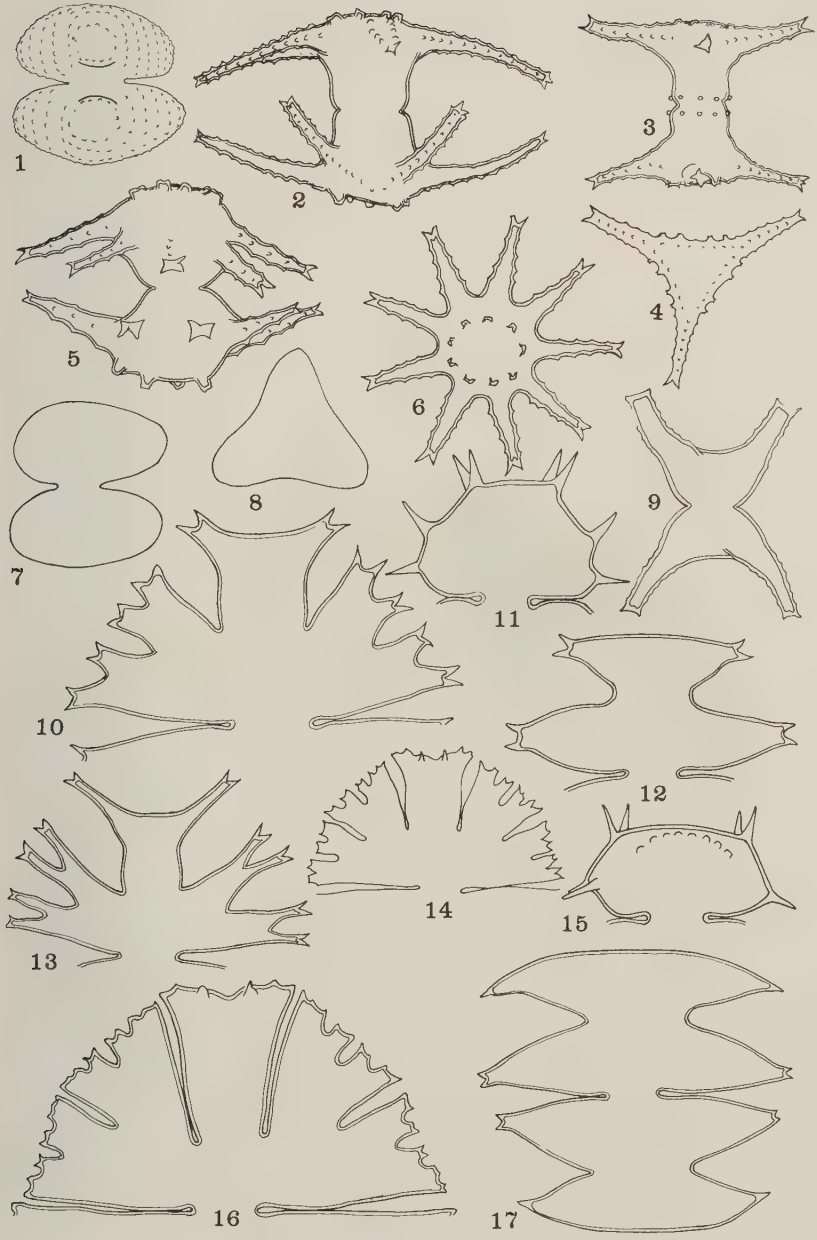
1. Staurastrum rugulosum De Bréb. × 440
2. S. pentacerum (Wolle) G. M. Smith, f. × 440

3 4. S. Pseudosebaldi Wolle, f. × 440

5 6. S. rotula Nordst. × 440

7–8. S. muticum De Bréb. × 440

9. S. tetracerum Ralfs. × 440
10. Micrasterias Crux-melitensis (Ehr.) Hass. × 440
11. Xanthidium cristatum var. uncinatum De Bréb. × 440
12. Micrasterias pinnatifida (Kuetz.) Ralfs. × 440
13. M. radiata Hass. × 282
14. M. apiculata (Ehr.) Menegh. × 220
15. Xanthidium antilopaeum var. polymazum Nordst. × 330
16. Micrasterias papillifera De Bréb. × 440
17. M. laticeps Nordst. × 220



Desmids of Isle Royale

NOTES ON BRYOPHYTES OF CENTRAL MICHIGAN

IRMA SCHNOOBERGER

AMONG the bryophytes collected in central Michigan by the writer from September, 1937, to January, 1939, are four species not previously reported from the state and a number of noteworthy range extensions of species within the state. The new species are indicated by an asterisk, and range extensions are given with each species.

All previous lists of Michigan bryophytes have been from collections made in the southern part of the state, chiefly around Ann Arbor, or from the northern part of the Lower Peninsula, Douglas Lake and Glen Lake, or from the Upper Peninsula and Isle Royale.

Central Michigan embraces an area offering various types of collecting grounds for the bryologist, though until very recently no one had done any bryological investigation in them. Much of the land is under cultivation, but great areas unfit for farming have been allowed to go back to woodland or have been reforested. Many of these woodlands or forests are of second-growth beech and maple, more or less open and on comparatively high, dry ground. Where the soil is lighter and poorer, extensive areas are covered with aspens, but there are occasional oaks or pines. Lakes are numerous, and marshes and bogs are plentiful. The lakes may have gravelly or sandy shores gradually sloping up to wooded ground or may be bounded by marshes, either open or partly wooded with cedar or tamarack or with a few elms and tag alders. Near Croton, in Newaygo County, there is a veritable desert of shifting sands with very sparse vegetation; just a few miles to the southeast, in Mecosta County, occur sandy plains spotted with pine and oak; at the tip of the "Thumb," in Huron County, are rocky shore lines and fair-sized sandstone cliffs. Each of these localities has a more or less distinct type of flora. In the cedar and cedar–tamarack swamps and bogs northern species occur, and in low marshes or open plains and farming country are found those previously reported only from

much farther south. Hence many appreciable northern or southern extensions of range have been noted.

In the classification of the species of mosses A. J. Grout's *Moss Flora of North America North of Mexico* has been followed. Unless otherwise stated, the determinations were made by the writer. Appreciation is expressed to Dr. W. C. Steere, who has verified all determinations.

In the list following only the wider extensions of range have been noted; the general habitat of each species is given. Duplicate specimens are on file in the University of Michigan Herbarium. All records reported are based on collections made by the writer.

List of Species

RICCIACEAE

Ricciocarpus natans (L.) Corda. — Terrestrial form. Growing over ground and old stumps in marshy lowland that dries out during the summer; south of Alma, Gratiot County. This is a northern extension of range from Washtenaw County.

RICCARDIACEAE

Riccardia latifrons Lindb. — On rotten stumps in cedar woods and swamps; Montcalm County. Southern extension from Glen Lake and Douglas Lake.

LOPHOZIACEAE

Lophozia incisa (Schrad.) Dumort. — Growing over mosses on rocky ledge along lake shore; Port Austin, Huron County. Southern extension from Douglas Lake.

JUNGERMANNIACEAE

Cephalozia bicuspidata (L.) Dumort. — In open woods on rotten wood and logs; Port Austin, Huron County, and north of Long Lake, Clare County. First report for the Lower Peninsula. Common in the Upper Peninsula and reported from Isle Royale.

LEJEUNEACEAE

Frullania Asagrayana Mont. — On trees in cedar swamp north of Long Lake, Clare County. Southern extension from Isle Royale, the Upper Peninsula, and the Douglas Lake region.

Frullania Brittoniae Evans. — On trunks of live maples and elms in open woods; Gratiot and Montcalm counties. Southern extension from the Upper Peninsula, and the Douglas Lake region.

*Frullania inflata Gottsche. — Determined by Dr. A. W. Evans. Collected by Dr. Steere in Washtenaw County and by the writer in Ionia County in the spring of 1938. Writer's specimen taken from base of poplar tree on bank of creek.

FISSIDENTACEAE

Fissidens Julianus (Mont.) Schimp. — Very abundant in intermittent creek bed; eastern Gratiot County. Previously known in the state only from Washtenaw County.

DICRANACEAE

Bruchia Sullivanti Aust. — Old sandy meadows; Van Buren County. Westward extension from Calhoun and Kalamazoo counties, where it was collected by Mr. Becker.

Pleuridium subulatum (Hedw.) Lindb. — Old sandy meadows; Van Buren and Gratiot counties. Western and northern extension from Kalamazoo County.

Oncophorus Wahlenbergii Brid. — Over soil and rotten wood in cedar swamps; Clare and Montcalm counties. Southern extension from Glen and Douglas lakes.

Dicranum montanum Hedw. — Bases of trees in low wet woods; Huron and Gratiot counties. Southern extension from Glen and Douglas lakes.

EPHEMERACEAE

Ephemerum spinulosum Schimp. — In sandy hillside meadow south of Alma, Gratiot County. Northern extension from Kalamazoo, Calhoun, and Washtenaw counties.

Barbula convoluta Hedw. — Determined by Dr. W. C. Steere. Sandy roadside ditch west of Ionia, Ionia County. Southern extension from Douglas Lake and the Upper Peninsula.

Tortella fragilis (Drumm.) Limpr. — Common on rocky ledges along shore of Lake Huron, Port Austin, Huron County. Southern extension from the Douglas Lake region.

Tortella tortuosa (Turn.) Limpr. — Plentiful on rocks at Broken Rocks, Port Austin, Huron County. Southern extension from Glen and Douglas lakes.

Tortula obtusifolia Schleich. (*Desmatodon arenaceus* S. & L.). — On rocks along lake front. Common at Broken Rocks and Pointe aux Barques, Port Austin, Huron County. Southern extension from northern tip of the Lower Peninsula.

*Tortula papillosa (Wils.) Spruce. — The first collection of this moss was made at Allegan, Allegan County, by the writer, and it was subsequently collected in Isabella, Gratiot, Montcalm, Ionia, Van Buren, and Ottawa counties. Dr. Steere located stations in Washtenaw and Livingston counties. It seems to be common locally, growing on the exposed or sunny side of old elms or over the roots of elms with other mosses. The material from Ottawa County was taken from *Celtis occidentalis* and Salix growing along Grand River. All specimens from Michigan have been on trees near streams, rivers, or lakes.

At first sight *T. papillosa* resembles an Orthotrichum, but upon closer examination the shiny costa shows up in a characteristic manner, and if one moistens the leaves they uncurl and reveal the excurrent costa and the spatula-shaped leaf with the ever-present propagula on the upper portion of costa and leaf. All these characters are easily seen with the aid of a hand lens.

ORTHOTRICHACEAE

Orthotrichum anomalum Hedw. — Covering large rocks on steep exposed hillside overlooking Grand River, west of Ionia, Ionia County. Fruiting freely. Southern extension from the Douglas Lake region.

MEESEACEAE

Paludella squarrosa (L.) Brid. — Growing with Sphagna and *Camptothecium nitens* in cedar–tamarack swamp north of Vestaburg, Montcalm County. Otherwise known from Isle Royale and Alger County. This is the first station for the Lower Peninsula.

BRYACEAE

Bryum cernuum (Sw.) Lindb. (*Bryum uliginosum* (Bruch) Br. & Sch.). — Determined by Dr. Steere. On high sandy bank overlooking Little Muskegon River, southeast of Croton, Mecosta

County. In good fruit. Known from the Douglas Lake region and Kalamazoo County.

Bryum ventricosum Dicks. — In swampy woods and cedar swamps north of Long Lake, Clare County, and north of Vestaburg, Montcalm County. Southern extensions from Douglas Lake and Isle Royale.

LESKEACEAE

Thuidium Philiberti Limpr. — Growing with other mosses over rotten logs in cedar swamps east of Gaylord, Otsego County, and west of Elmhall, Montcalm County. Previously known from Isle Royale and the Porcupine Mountains.

Leskea obscura Hedw. — Bases of trees in open woods; Gratiot County. In fine fruit. Northern extension from Van Buren County.

Anomodon tristis (Cesati) Sull. — Base of tree in low, open woods west of Elm Hall, Montcalm County. A very small moss and evidently not common, since only one collection has been made so far. Previously known only from the Huron Mountains.

Myurella julaceae (Vill.) Br. & Sch. — Common on rock ledges along lake shore; Port Austin, Huron County. Also known from the rocky shores of the Upper Peninsula and the Douglas Lake region.

HYPNACEAE

Brachythecium acutum (Mitt.) Sull. — In cedar swamp east of Gaylord, Otsego County, and in low open woods just back from lake shore, Port Austin, Huron County. Previously known only from Washtenaw County.

Brachythecium campestre B. & S. — On bank in shaded ravine east of South Haven, Van Buren County. Otherwise known from Washtenaw County and the Porcupine Mountain region.

Brachythecium cyrtophyllum Kindb. — Common on the bases of trees in open woods; Isabella, Gratiot, Huron, and Ionia counties. Southern extensions from the Douglas Lake region.

*Brachythecium digastrum C. Muell. & Kindb. — Over wet logs near river southwest of Alma, Gratiot County. Many setae left on plants but few capsules. This is the first report for Michigan and so far the only station.

Bryhnia novae-angliae (Sull. & Lesq.) Grout. — Common locally in open woods; Gratiot and Van Buren counties. Otherwise

known from Glen Lake and the Douglas Lake region, Grand Traverse County, and the Upper Peninsula.

Eurynchium strigosum (praecox) var. robustum Röll. — In open moist woods; Mecosta and Van Buren counties. Otherwise known from Isle Royale and Washtenaw County.

Cratoneuron commutatum (Hedw.) Roth. — Cedar swamp east of Gaylord, Otsego County. Otherwise known only from Alger County.

Hygroamblystegium irriguum (Wils.) Loeske. — Growing over stones in running brook southwest of Ionia, Ionia County. Southern extension from Douglas Lake and the Upper Peninsula.

*Hypnum molluscum Hedw. — This is a beautiful feathery moss common along the borders of cedar–tamarack swamps and wet woods where the shade is not too dense. Its soft plumelike appearance and bright yellow-green color make it very conspicuous. It usually grows in large mats, little mixed with other mosses; Gratiot, Clare, and Isabella counties.

Hypnum cupressiforme Hedw. — On rocky ledges along lake shore at Broken Rocks, Port Austin, Huron County. Southern extension from the Douglas Lake region and Alger County.

Amblystegiella subtilis (Hedw.) Loeske. — On bases and trunks of trees in shady woods; Huron, Gratiot, Newaygo, and Otsego counties. Otherwise known from the Upper Peninsula and the Douglas Lake region.

Pylaisia Selwynii Kindb. — On trunks of trees in open woods; Mecosta, Montcalm, Gratiot, and Isabella counties. Southern extension from Glen and Douglas lakes and Ontonagon County.

FONTINALACEAE

Dichelyma capillaceum (Dill.) B. S. G. — Common on tree bases, over bushes, and old stumps in low wet river bottoms flooded at high water; Gratiot County east of Alma, and Van Buren County east of South Haven. Otherwise known from Washtenaw County.

Fontinalis Lescurii Sull. — In intermittent stream bed on tree roots and in low river bottom over roots and bushes; Gratiot County. Southern extension from the Douglas Lake region.

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STUDIES IN THE GENUS AGARICUS*

ALEXANDER H. SMITH

THE genus Agaricus consists of a group of species characterized by purple-brown spores, free lamellae, the presence of an annulus, the absence of a volva, and the stipe, which is readily separable from the tissue of the pileus. The name "Agaricus" is used here in preference to "Psalliota" in order to comply with the International Rules of Nomenclature.

It is always very easy to recognize an Agaricus, but, with a few exceptions, the recognition of species is much more difficult. Owing to incomplete descriptions on the one hand and the lack of sharp, distinctive specific characters on the other the modern student of the group is faced with many difficult problems.

The characters most frequently used in classifying the species are the nature and position of the annulus, the color and nature of the surface of the pileus, the taste, odor, color, and color changes of the flesh of any part of the fruiting body, spore size and shape, and color of the immature lamellae. Within broad limits the stature of the fruiting body is also important.

The cuticle of the pileus of most species consists of radially arranged fibrils composed of fascicles of hyphae. In some species this layer remains appressed during the entire development of the fruiting body. In others the fibrils tend to become arranged into scales, which in turn may remain appressed or become somewhat recurved. At best, the difference between a scaly pileus and one which is fibrillose is purely a question of degree. Weather conditions often cause a great deal of variation, as in *A. crocodilinus* and *A. praerimosus* (23). Thus, although the character of the surface of the pileus does furnish some information of value to the taxonomist, it must be used with caution. The same is true of the color of the fibrillose surface covering. The only satisfactory approach to the problem of describing color in such a way that a reader may obtain an accurate conception of the color value expressed is the use of a color chart.

* Papers from the University of Michigan Herbarium.

The color of the young gills, particularly the presence or the absence of pink, has always been given great importance in the genus, and does furnish us with a reliable character in a broad sense. Unless pronounced, the different tones of pink or a duller flesh color are hardly of specific value, and in species in which they are usually pale it is not surprising to find occasional specimens with the pinkish color absent. *A. placomyces* is a good example.

The character of the annulus, whether it is double or single, is also used considerably. This character is reliable so far as the doubleness is concerned. If a collector finds a specimen the annulus of which has colored patches of tissue on the under side, he may be sure that it falls into the group so distinguished. If, however, the specimen has an annulus which is smooth or merely fibrillose on the under side, he is not in position to make an accurate decision. He may have a species which typically has a double ring, but in the specimens at hand the telltale patches may have been lost. A complete developmental series is necessary to establish the character of singleness. Much confusion has been caused in the group of species related to *A. silvaticus* because of the unreliability of this character.

Of the microscopic characters, spore size and shape are the most constant and valuable. Lactiferous ducts are quite common in the flesh of most of the species, and there are no sharply distinctive types of cystidia, as in the genus Mycena. Clavate, somewhat enlarged sterile cells are present on the gill edges in certain groups of species, but they show little difference in shape and size.

In order to study the constancy of spore size one must first have access to large numbers of collections from various localities, preferably of material identified by a single investigator. These conditions are obviously difficult to meet. Wherever I have been able to realize them, as in studying *A. subrutilescens*, *A. silvicola*, and *A. diminutivus*, I have found spore size and shape to be remarkably constant. Abnormally large spores are often observed in mounts of certain species, and as a result one might be tempted to decide that spore size is not constant. Such a conclusion would not be justified, however, since one usually finds that the supposed variation is constant for a species, as in *A. crocodilinus*.

Because of the lack of accurate information on the shape and size of the spores in American species of Agaricus I have brought together

in Figures 1–4 drawings of the spores from the American types, so far as they have been available.

The study of the type material of species described by Atkinson, Peck, and Murrill has been made possible through the courtesy of Professor H. M. Fitzpatrick, of Cornell University, Ithaca, New York; Dr. H. D. House, New York State botanist, New York State Museum, Albany, New York; and Dr. Fred J. Seaver, of the New York Botanical Garden. I also wish to express my thanks to Dr. W. A. Murrill, of Gainesville, Florida, and to Dr. S. M. Zeller, of Corvallis, Oregon, for material of some of the species they have recently described. The photograph of *A. Pattersonae*, which was found with the type at Albany, New York, is reproduced here with the permission of Dr. House, who very kindly had a copy made for that purpose. I took the remaining photographs and made the collections cited by number. They are deposited in the Herbarium of the University of Michigan. The field work on the Pacific Coast was carried out during the seasons of 1935 and 1937, with the aid of grants from the Horace H. Rackham School of Graduate Studies of the University of Michigan.

All color names in quotation marks are taken from R. Ridgway, *Color Standards and Color Nomenclature*, Washington, D.C., 1912. The drawings were made with the aid of a camera lucida and are reproduced at a magnification of approximately 1300 times.

List of Species

Agaricus augustus and closely related species

Agaricus augustus Fr. (Fig. 1*a*). — Pileus (10) 18–35 (45) cm. broad, cylindric with a flattened apex in button stages or tending toward convex, becoming broadly convex with a flattened apex and finally plane or with a broad flattened umbo, surface dry, densely covered at all stages by long coarse fibrils which become arranged into more or less fasciculate-appressed scales toward the margin, the disc remaining evenly and densely fibrillose but often becoming areolate, color of fibrils "wood-brown" to pale cinnamon-brown, becoming darker sordid brown over the disc, the whitish to faintly yellowish ground color showing toward the margin, margin usually fringed with fibrils; flesh 1–2 cm. thick (in very large fruiting bodies the flesh is thin in relation to the

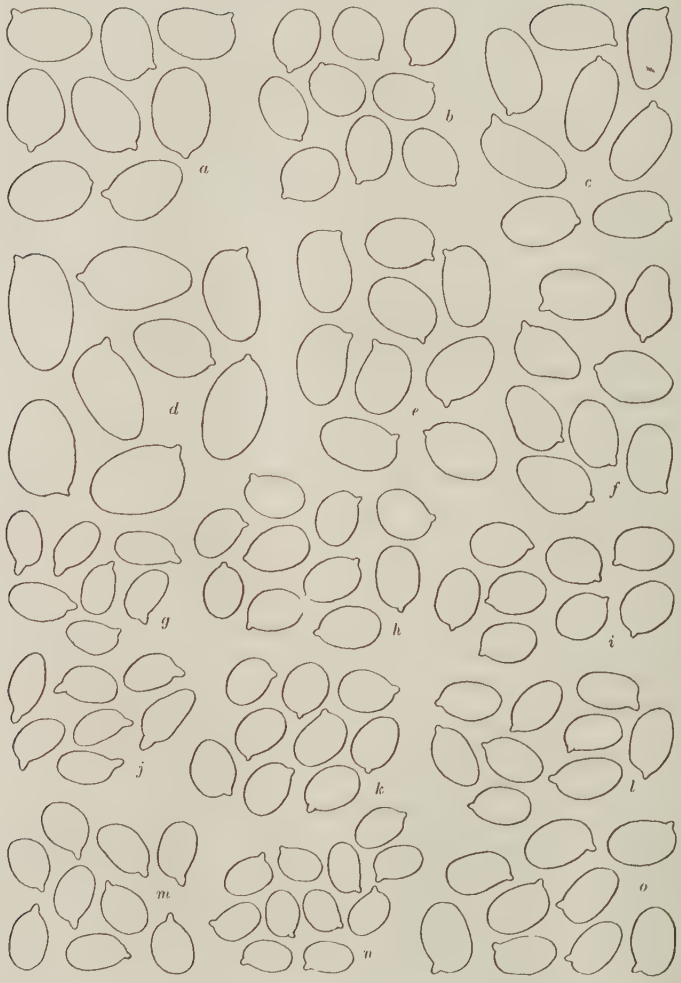

Fig. 1. a, *A. augustus;* b, *A. subrufescens;* c, *A. perrarus;* d, *A. crocodilinus;* e, *A. arvensis;* f, *A. arvensis* var. *palustris;* g, *A. magniceps;* h, *A. silvicola,* robust form; i, *A. silvicola,* typical form and type of *A. abruptibulbus;* j, *A. magniceps;* k, *A. floridanus;* l, *A. albolutescens;* m, *A. albosanguineus;* n, *A. cretacellus;* o, *A. ciscoensis*

size of the cap), white but becoming slightly yellowish on the surface, no color change noticed when the fresh flesh was cut or bruised, odor slight, taste distinctly like that of almonds; lamellae white at first and remaining so until near maturity, becoming "deep brownish vinaceous" or more pinkish for a short time before becoming black, remote, narrow, moderately close, often crisped, edges even; stipe 10–12 (18) cm. long, 2–6 (9) cm. thick, equal, clavate or ventricose, base immersed in the soil and at times subradicate, stuffed solid, becoming hollow in age (especially at the base), whitish to very pale buff and densely fibrillose-scaly below the annulus, silky, glabrous, and whitish above, not changing color readily when handled but becoming sordid brown slowly after being bruised or when dried (not at all yellowish when dried); annulus double, median to superior, with cottony "wood-brown" patches on the under side; spores 7–10 × 5–6 μ, broadly ellipsoid, dark chocolate-brown under the microscope, with a hyaline oblique apiculus.

Gregarious to scattered in mixed forest of redwoods, Brookdale, California, and under spruce near Smith River, California, during the seasons of 1937 and 1938. The notes for the description given above were based upon the Smith River collection. Miss E. E. Morse, of Berkeley, very kindly sent to me the material collected at Brookdale.

The outstanding characters of this species are the colors, the stipe with its rather deeply buried base, the immense size, the almond-like taste of the raw flesh, and the spores. The color of the disc is dull brown, and was very aptly described by Fries (6) as "dilute brunneo." The conspicuous fibrillose scales are concolorous with the disc or a darker dull brown. This color difference is very distinct and readily separates *A. augustus* from the two reddish to yellowish tawny species, *A. perrarus* and *A. subrufescens*, neither of which has a stipe base which penetrates into the soil. The color of the flesh beneath the scales on the pileus of *A. augustus* is whitish at first, but may soon be tinged dull lemon-yellow. Fries's illustration (7) shows the color of the scales almost exactly as I found them in my collection. In age or when bruised the stipe slowly becomes "army-brown," in contrast with the "warm buff" color of the bulb and the surrounding mycelium of *A. perrarus*. Fries (6) described the stipe of *A. augustus* as

glabrous, but floccose just below the annulus and unpolished. This indicates that the stipe was peronate up to the annulus, but that the sheath did not readily tear into scales. The stipes of the California collections had such a sheath, but in them it broke up into fibrillose patches. I have observed specimens of *A. perrarus* with a smooth untorn sheath as well as some with the sheath torn into scales, and as a result I am not inclined to consider significant this apparent discrepancy between Fries's description of *A. augustus* and my specimens. The gills in my specimens, although remaining white during most of their development, did exhibit pinkish to pinkish brown tints for a short time. This is not in accordance with Fries's descriptions. From my observations on *A. perrarus* and other species, however, I am sure that the presence or the absence of pink in young gills of species of Agaricus is not an infallible character, and that a certain amount of variation can reasonably be allowed. In addition to the slight difference in gill color the stipes of my specimens showed a greater tendency to become hollow than is indicated by Fries. Here again the difference seems to be slight and within the limits of expected variation.

Under the name *A. villaticus* Brond., Hotson and Stuntz (9) report from Washington specimens which are apparently this species. In the specimens they found, the color changes were more pronounced than in mine. This is a variation which is to be expected. Schäffer and Möller (22) have given a detailed account of *A. vaporarius*, under which they list *A. villaticus* Brond. as a synonym and state that it has subglobose spores along with other characters which readily distinguish it from the Washington specimens. An illustrated specimen which Hotson and Stuntz (9) identified as *A. perrarus* is also strongly suggestive of *A. augustus*, and should be placed there in spite of the apparent differences in annulus and length of stipe which these authors point out. In my concept of *A. augustus* I have adhered to the most nearly complete of the Friesian (6) descriptions. It is obvious that the species has been variously interpreted by European investigators. Ricken (21) has placed here a species very similar to *A. crocodilinus* of the *A. arvensis* group. Konrad (12) has apparently followed Maire (16) in placing *A. perrarus* Schulz. under *A. augustus*. Rea (19) considered *Psalliota villatica sensu* Bresadola

to be identical with *A. augustus*. Bresadola's (3) illustration of *P. villatica* strongly suggests, however, a relationship with *A. crocodilinus*. Schäffer and Möller (22), who apparently have retained the Friesian concept of *A. augustus*, have pointed out the possibility of confusing *A. vaporarius* with it. Unfortunately they did not publish a detailed account of the former plant. Lange (15) recently published a good illustration of *A. augustus*. The color of the young gills as he has pictured it is very similar to the pale grayish vinaceous shades I have observed in young specimens. For additional comments see *A. perrarus*.

Agaricus perrarus Schulzer (Fig. 1*c*). — Pileus 8–15 cm. broad, convex or obtuse, becoming more or less expanded, finally nearly flat, surface dry, innately fibrillose at first, in age spotted by appressed-fibrillose scales or the fibrils merely loosely arranged in fascicles, disc remaining innately fibrillose, color of fibrillose scales and the disc "ochraceous tawny," the ground color "cinnamon-buff" or more yellowish, margin often fibrillose-appendiculate with yellowish fibrils; flesh soft, white, moderately thin (8–15 mm.), odor faintly pungent, taste strong and resembling bitter almonds; lamellae crowded, rather remote, whitish to grayish pink when young, slowly becoming dull chocolate-brown, edges pallid to yellowish and slightly uneven; stipe 8–15 cm. long, 10–15 mm. thick, equal above an abrupt bulb which is flattened below, stuffed solid with a white silky pith, hollow in age, peronate with a white fibrillose sheath below the annulus, the sheath either remaining smooth or becoming torn into white fibrillose patches which become yellowish in age or if bruised, whitish and silky above the superior annulus; annulus buffy white and silky above, the under side colored like the pileus and torn into floccose patches; spores 8–10 (12) × 4–5 (6) μ, ellipsoid, dull grayish brown under the microscope, dull chocolate-brown in mass.

I have found this to be a rather abundant species in northern California (3637, 3699, 8215, 8185, 9475). It prefers conifer habitats there, and seems to be most frequent along or near the edges of dense second-growth stands of spruce. I have collected it under pine in Oregon (8161). The spores illustrated were taken from a fruiting body of collection 8161, from Lincoln County, Oregon, October 26, 1937.

Zeller (25) has reported this species under the name *A. augustus*.

Larger spores, as indicated by the measurements in parentheses in the description on page 113, are occasionally found in mounts, but not in sufficient numbers to warrant being included in the typical size range for the species. In many of my specimens the lamellae were by no means pure white at first; those that were soon became tinged with grayish pink. They were never found to be so bright a pink as they are in *A. subrufescens*, however. *A. perrarus* has been placed in synonymy with *A. augustus* by some, but is very distinct. The abrupt bulb, or at least the flattened base of the stipe, is a constant feature, and the yellow to ochraceous tawny colors are equally distinctive, especially in dried specimens. The gill colors of *A. augustus* and *A. perrarus* are apparently about the same, sometimes without any pink (see Zeller's comments) and sometimes faintly flushed grayish pink (my own observations, also on Oregon specimens). Because of the differences in gill color which I have observed in *A. perrarus*, I hesitate to use the character as one of more than secondary importance. Lange (14) first recognized *A. perrarus*, but described its spores as 7.5 × 5–5.5 μ. Later (15) he adopted the name *A. subrufescens*, but retained the concept that one was a synonym of the other. I have had the opportunity to examine ample material of both, and have found the difference in spore size to be constant. This difference is correlated with others of less importance, such as pinker gills and reddish brown colors of the pileus in *A. subrufescens*. I have used Bresadola's interpretation of *A. perrarus* here because it is the most authentic account available. It is evident from the literature that Schulzer was in close touch with Bresadola, who was thus in a more favorable position than anyone else to evaluate Schulzer's specimens. The illustration of *A. perrarus* published by Hotson and Stuntz (9) shows the typical stipe base of *A. augustus*, but they describe the stipe of the former plant as equal and the base as bulbous.

Agaricus subrufescens Pk. (Fig. 1*b*). — I have collected this fungus in Michigan and compared the specimens with Peck's type, but cannot add any information to that found in Kauffman's account (10). It has been reported from Oregon by Zeller (25) and from Washington by Hotson and Stuntz (9). Owing to a marked discrepancy in spore size in the report of the Washington specimens, it is clear that a different species is repre-

sented. If *A. subrufescens* occurs in Europe it has probably been known under the name *A. peronatus* Massee, which is described as having spores 6 × 4 μ. Until more critical studies of the English species have been made and the spore measurements are verified, it does not seem advisable to adopt the latter name. The drawings of the spores in Figure 1*b* were made from type material.

AGARICUS ARVENSIS AND CLOSELY RELATED SPECIES

AGARICUS CROCODILINUS Murrill (Fig. 1*d*; Pls. I–II). — Pileus 10–35 cm. broad, convex, remaining broadly convex, surface dry, fibrillose, the fibrils soon becoming arranged in fascicles or appressed scales, as expansion takes place the scales recurve somewhat, finally the flesh becomes deeply cracked into a series of overlapping scales which in extreme cases (usually on fruiting bodies exposed to the sun) are 1–2 cm. long, sometimes the surface remains merely appressed-fibrillose and smooth (usually on fruiting bodies in shady places), color white or tinged "cinnamon-buff" over the disc, the tips of the scales frequently tinged brownish (near "avellaneous"), no yellow color noted at any stage either when wet or dry; flesh very thick (up to 3 cm.), firm, white, unchanging, odor and taste not distinctive or the latter slightly bitter upon continued chewing; lamellae broad, touching the stipe at first, at times becoming remote in age, close, many-forked near the base, "light russet-vinaceous" in small closed buttons, dull chocolate-brown at maturity, not truly pink at any stage; stipe (7) 10–15 cm. long, 2–4 (7) cm. thick, subfusiform to clavate with a narrowed base, stuffed solid, becoming hollow, white and unchanging when bruised, becoming sordid reddish brown above in age, base at first with concentric rows of scales left by the universal veil tissue, glabrous and silky above; annulus superior, double, sometimes leaving two distinct rings on the stipe, the lower one more or less frayed or cracked, sometimes the lower ring adheres to the under side of the upper ring and forms large "cinnamon-buff" areolate patches; basidia four-spored; spores (7) 8–11 × 5.5–7 μ, in many pilei comparatively large numbers of spores 12–16 × 7–8 μ are found; cheilocystidia, 42–50 × 7–12 μ, form a sterile band on the margins of the gills; lactiferous hyphae are present in the pileus and gill trama.

Growing singly to scattered in pastures, meadow lands, or on waste ground. I have not been able to locate the type of this species, and so have used for the drawings spores from collection 8462. The fruiting bodies shown on Plates I–II, which are from the same collection, are of young specimens. Zeller (26) has reported the species from Oregon, and it is not uncommon in northern California. The description and the photographs are given here in order to facilitate a critical comparison of Murrill's species with European species of the *A. arvensis* group. *A. Bernardii* is apparently very close to it, but is described as having an annulus which soon disappears and flesh which finally is stained reddish brown. Lange (14), who collected a closely related species, used for it the name *Psalliota villatica* Brond. He points out that *A. augustus* (*Psalliota*) *sensu* Ricken (21) and *Psalliota lepiotoides* may be the same as his *Psalliota villatica*. All of these are very similar to *A. crocodilinus*. Schäffer and Möller (22) have recently discussed a closely related series of forms, and have given the name *Psalliota arvensis* subsp. *macrospora* to one of them. Apparently all accounts of these European species differ in minor characters from *A. crocodilinus*.

Agaricus arvensis Fr. (Fig. 1*e*). — Pileus 4–15 cm. broad, convex to subplane, buttons ovoid to subcylindric, surface dry, innately white-fibrillose, the fibrils sometimes converging to form appressed scales, with a narrow sterile margin frequently decorated with veil remnants, color white or tinged creamy to yellowish on the disc; flesh up to 1 cm. thick, firm, white, staining yellow near the cuticle when bruised, odor none, taste mild or very slightly of almonds; lamellae remote, rather broad (8–12 mm.), close, nearly equal, white or faintly grayish at first, slowly changing to dull vinaceous brown with a pinkish tint, finally dark blackish brown (typically "avellaneous" in late stages of immaturity); stipe 6-12 cm. long, 1-2 cm. thick, equal above a slightly clavate base, stuffed, becoming hollow, white, changing to yellowish in age, glabrous and silky above and below the superior annulus; annulus double, smooth and silky on upper side, with areolate cottony patches beneath, white or tinged yellowish with age; basidia four-spored; spores 7–9 (10) × 5–6 μ, ellipsoid, fuscous brown under the microscope.

Gregarious on dung and sod in or along the edges of pastures.

The spores figured are from collection 9066, which was found near Smith River, California, in 1937. After an examination of the spores of various collections determined as *A. arvensis* by American investigators it became apparent that two species have been included under this name in North America. One is characterized by spores which measure 5–6.5 × 4–5 μ, and the other by spores as given in the foregoing description. I have examined collections of the latter from New York, Michigan, Ohio, and California, and believe that it is the species which should bear the name *A. arvensis*. Nearly all Kauffman's collections are of the small-spored species. For additional comments upon it see *A. silvicola*.

Agaricus arvensis var. **palustris,** var. nov. (Fig. 1*f*). — Pileus 10–35 cm. latus, convexus demum late umbonatus, siccus, fibrillosus, nitens, demum subsquamulosus, albidus; caro 1–2 cm. crassa, albida, demum luteo-maculosa, cum odore amygdalino et sapore; lamellae latae (1–1.5 cm.), confertae, albidae demum brunneo-fuscae; stipes 10–30 cm. longus, 2–3 cm. crassus, clavatus, albidus demum luteo-maculosus, sericeus; annulus pendulus, amplus, duplicatus, exterior revolutus, radiatim fissus; sporae 7–8.5 (9) × 4.5–5 μ. — Specimen typicum legit A. H. Smith n. 7546 prope Kent Lake, Oakland Co., Mich., Sept. 13, 1937; in Herb. Univ. Mich. conservatum.

Pileus 10–35 cm. broad, broadly ovoid to convex when young, becoming broadly umbonate, convex or plane, surface dry, appressed silky-fibrillose, shining in age, becoming minutely fibrillose-scaly around the disc, white or shining white, disc often creamy or yellowish, the fibrillose scales sometimes become brownish; flesh thick (1–2 cm. ±), firm, coarse, white, staining slightly yellowish when bruised, especially when moist, odor and taste strong, resembling that of almonds; lamellae broad (1–1.5 cm.), close, remote from the stipe, white, remaining so until nēar maturity, becoming brownish then pale to dark fuscous brown, edges even; stipe 10–30 cm. long, 2–3 cm. thick, equal above a massive clavate bulbous base (4–5 cm. thick), stuffed, becoming hollow, white, staining yellowish where handled, silky and shining above the median to superior annulus, appressed-fibrillose with innate fibrils below, not sheathed; annulus flaring, ample, membranous, double, striate and silky above, lower layer cracked

into irregular yellowish cottony-fibrillose patches; cheilocystidia in large clusters or forming a sterile band on the edge of the gill, 18–28 × 8–15 μ, clavate, yellow when revived in KOH; basidia four-spored; spores 7–8.5 (9) × 4.5–5 μ, usually ovoid, dark fuscous under the microscope, with an inconspicuous oblique, hyaline apiculus; lactiferous hyphae in cap and gill trama hyaline, contorted and highly refractive.

Gregarious on low swampy ground under elm, ash, and red maple. Hitherto the variety has been found only in the vicinity of South Lyons and Kent Lake, Oakland County, Michigan; it seems to fruit during rather dry seasons.

The figures of the spores were drawn from type material. They are practically of the same size as spores of *A. arvensis*, but the difference in shape is conspicuous when mounts of both are compared under the microscope. A small number of ellipsoid spores are nearly always found in mounts of the variety, a circumstance that indicates its relationship to *A. arvensis* rather than to *A. silvicola*. The strong odor of almonds, the habitat, and the difference in the shape of the spores all distinguish it from the former species.

AGARICUS SILVICOLA (Vitt.) Sacc. (Fig. 1 *h–i*). — *Agaricus abruptibulbus* has been correctly referred as a synonym of *A. silvicola*. The spores shown in Figure 1*i*, are from the type of *A. abruptibulbus* and measure 5.5–6.5 × 4–4.5 μ. In the numerous collections I have examined the spore size has been found to be a remarkably constant character, and one which serves better than any other to distinguish the species from *A. arvensis*. In North America, and very likely in Europe also (see Schäffer and Möller, 22), a robust form occurs which has been frequently mistaken for *A. arvensis*. Kauffman's account (10) of the latter is of such a form, and Peck also had placed it in *A. arvensis*. The spores illustrated in Figure 1*h*, which are taken from one of Kauffman's collections determined as *A. arvensis*, illustrate their similarity to those of *A. silvicola*. For a comparison of the macroscopic characters of the two forms see Kauffman's description of *Psalliota arvensis* and *P. abruptibulba*.

AGARICUS MAGNICEPS Pk. (Fig. 1 *g, j*). — Pileus 5–12 cm. broad, convex, becoming plane, surface dry, appressed-fibrillose, the fibrillose layer frequently breaking up into minute patchlike

appressed scales, in age becoming areolate around the disc, entirely white or creamy white, the disc occasionally somewhat avellaneous, the scales more or less pale crust-brown in age; flesh moderately thick, white, not changing to yellow when bruised or in drying (plants collected in dry weather), odor and taste slight, somewhat nutty; lamellae close, broad, remote, white, slowly changing to grayish vinaceous and finally dull reddish brown, edges even; stipe 7–10 cm. long, 1–2.3 cm. thick, with a clavate to subbulbous base 3–4 cm. thick, stuffed, becoming hollow, white, silky and shining above, more or less cottony fibrillose below the median annulus, not sheathed; annulus white, smooth and silky above, fibrillose beneath, with thick cottony white patches on the under side near the margin; basidia four-spored; spores 6–7.5 (8) × 3–3.5 (4) μ, narrowly ellipsoid to subovoid, with a very prominent obtuse hyaline apiculus, pale reddish brown under the microscope.

Spores of the type are illustrated in Figure 1*g*. They are rare, appear immature, and measure 5–6 × 3–3.5 μ. The fruiting bodies in the type collection are very poorly preserved. In the single collection from Michigan, from which the description was drawn, the spores were slightly larger but of the same shape (Fig. 1*j*). The pronounced apiculus and the pale reddish brown color are their outstanding characters. No color change to yellow was noted on the Michigan collection, but parts of the type have dried pale yellowish, a fact which, in addition to the pale colors and its resemblance to *A. arvensis* in stature, places the species in this group.

Agaricus floridanus Pk. (Fig. 1*k*). — The spores measure 5–6 × 4–4.5 μ and appear nearly black under the microscope. In the only specimen with a well-preserved annulus the latter was found to have two distinct marginal limbs. It is difficult to determine from this whether the ring is truly double or single. Because of the resemblance of the fruiting bodies to robust forms of *A. silvicola* I place the species here provisionally.

Agaricus albolutescens Zeller (Fig. 1*l*). — The spores were drawn from type material which Dr. Zeller sent to me for that purpose. They measured (5) 6–6.5 (7) × 3.5–4 μ. During the fall of 1937 I collected this species in northern California. The viscidity mentioned in the original description is more apparent

than real. In other words, it is not due to a typical gelatinous layer of hyphae, and a true pellicle is not present. The stickiness is due to the rather slight gelatinization of the surface fibrils which normally cover the pilei of species in this genus. I have observed a similar viscidity or pseudoviscidity on species of Inocybe and in Inoloma, a subgenus of Cortinarius. Apparently the effect is produced by prolonged wet weather. *A. albolutescens* is most closely related to robust forms of *A. silvicola.*

Agaricus cretacellus Atk. (Fig. 1*n*). — Pileus 4–7.5 cm. broad, ovoid to convex, with a somewhat flattened disc, becoming plane or slightly umbonate, thin, smooth, subviscid when moist but no gelatinous pellicle present, surface of appressed silky fibrils which may converge to form inconspicuous appressed scales, margin silky and at times decorated by fragments of the veil, pure white, only occasionally staining slightly yellowish, in age sometimes pinkish near the margin as gill colors show through the flesh; flesh whitish or tinged pinkish near the lamellae, odor faintly pungent, taste mild or slightly amygdaline; lamellae narrow, 3–4 mm., narrowed behind, equal, approximate to the stipe at first but becoming remote in age, crowded, white when young, slowly changing to "pale vinaceous fawn" and finally "army-brown," never becoming black, edges even; stipe 8–10 cm. long, 6–10 mm. thick, clavate to bulbous, tapering slightly toward the apex, stuffed with a silky somewhat indistinct pith, white and smooth above the annulus, white and minutely floccose to subscaly below, not staining yellow; annulus superior, with cottony areolate patches on the under side, silky and smooth above, white; spores 5–5.5 × 3–3.5 μ, ellipsoid, pale chocolate-brown under the microscope; basidia four-spored; cheilocystidia not differentiated.

Gregarious on leaf mold in mixed forests. The description was drawn from specimens collected at Cades Cove, Tennessee, during the summer of 1937. The species is readily distinguished by its small spores and dull brown gills. The resemblance to *Lepiota naucina* is rather striking, but the spore color distinguishes it at once.

Agaricus albosanguineus Hotson & Stuntz (Fig. 1*m*). — The spores were drawn from material sent to me by Professor Hotson. This species has been described as having a single annulus, but, to

judge from the original description, the authors did not have enough material of all stages to enable them to study variation. In *A. silvicola*, to which *A. albosanguineus* is very closely related, the double annulus is not always discernible, and in the *A. silvaticus* group in general I have found it to be very unreliable. Hence I am inclined to disregard this character in comparing their species with those described from Europe. As Hotson and Stuntz have pointed out, *A. exsertus* Viv. *sensu* Rea (19, p. 88) does not agree in its characters with their species. However, *Psalliota Benesi* Pilat seems to be very similar to *A. albosanguineus*, and I seriously doubt whether the latter can be maintained as a species. Pilat's Latin description is translated here in order that American investigators who do not have access to the original may compare the accounts of both species.

Psalliota Benesi Pilat. — Pileus white, fleshy, dry, at first subglobose, next hemispheric-campanulate, later explanate, 6–15 cm. in diameter, at first glabrous, smooth, then somewhat squamulose; stipe white, very long (regularly 16 cm.), often twice as long as the pileus is broad, cylindric, base somewhat incrassate, solid at first, becoming hollow, more or less flexuous, lower portion slightly floccose-squamulose, above the annulus as well as the upper surface of the annulus thinly fibrillose. Annulus large, double, dentate on under side. Flesh white, blood-red when bruised, then fuscescent. Spores ovato-ellipsoid, 5–5.5 × 3.5–4 μ, badious, with a thick wall, uniguttulate. Basidia clavate, hyaline, with a thin wall, with four sterigmata, 18–25 × 6–8 μ. Sterigmata narrow, 2 μ long. Context of lamellae (central portion) of thin-walled, hyaline smooth hyphae 4–5 μ in diameter.

AGARICUS SILVATICUS AND CLOSELY RELATED SPECIES

AGARICUS SUBRUTILESCENS (Kauff.) Hotson & Stuntz (Fig. 2*c*; Pl. III). — The drawings of the spores were made from the type. Spores of twenty-one collections of this species have been examined, and they have been found to be remarkably constant in size. The range for the entire number of collections was (4.5) 5–6 × 3–3.5 μ. The species is common in the Cascade Mountains of Oregon and along the coast of northern California. It is readily distinguished by the dark vinaceous brown fibrils of the pileus and the white fibrillose patches or scales below the annulus on

the stipe. In many of my specimens the annulus was typically "single," but in the majority it was "double," as in *A. silvicola.* In many, also, the veil remnants which usually form the patches on the under side of the ring were aggregated along the margin. They caused it to appear quite thick and made it difficult to decide in which of the two categories the ring should be classed. To judge from my observations on this species, *A. silvaticus,* and *A. glaber,* the situation is by no means rare, and hence in this group it is impossible to use the character to advantage taxonomically.

AGARICUS GLABER Zeller (Fig. 2*b*; Pls. IV–V). — The drawings were made from type material. The very pale colors of the pileus in young stages distinguish it from *A. silvaticus,* to which it is closely related. Very old specimens can be readily distinguished by their glabrous dark brown pilei.

AGARICUS SILVATICUS Fr. (Fig. 2*a*; Pls. VI–VII). — Pileus 4–10 (12) cm. broad, broadly convex, becoming plane, dry, surface covered by a fibrillose cuticle when young, cuticle "russet," as expansion takes place the fibrils of the cuticle become aggregated into appressed scales near the margin, at maturity the disc remains russet or darker and the scales become "tawny" or paler with the white ground color showing between them, in age the scales tend to become "pecan brown" or more reddish; flesh moderately thick and firm, rather moist, whitish or pallid, slowly becoming reddish brown, odor none, taste slightly amygdaline; lamellae crowded, narrow to moderately broad, edges even, "light grayish vinaceous" before the veil breaks, "brownish vinaceous" near maturity, finally becoming "army-brown" or darker; stipe 6–11 cm. long, 1–2 cm. thick, tapering slightly above a subbulbous base, hollow, appressed-silky above and below the superior annulus, whitish but becoming tinged pinkish brown; annulus whitish with vinaceous-tinged floccose scales or patches on the under side, sometimes merely white-fibrillose below; spores 5–6 × 3–3.5 (4) μ, broadly ellipsoid, fuscous brown under the microscope, dull chocolate-brown in mass.

This species is found sporadically, but often abundantly, under Douglas fir and other conifers in Washington, Oregon, and California. The spores for the illustration were drawn from a specimen collected by Lars Romell in Sweden and deposited at the

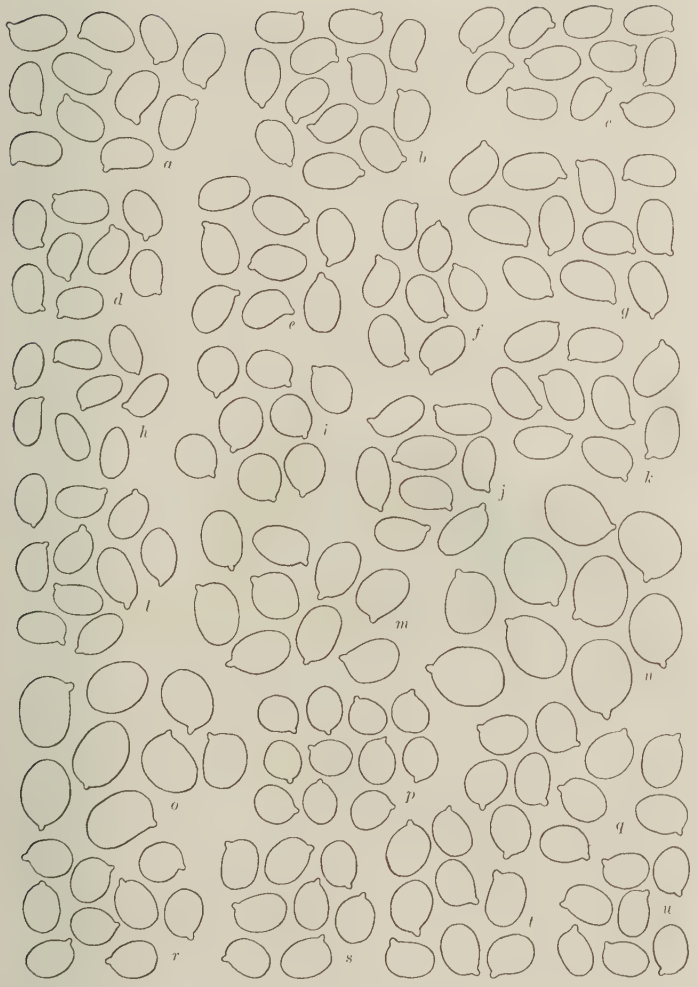

FIG. 2. a, *A. silvaticus;* b, *A. glaber;* c, *A. subrutilescens;* d, *A. rubribrunnescens;* e, *A. placomyces;* f, *A. meleagris;* g, *A. haemorrhoidarius;* h, *A. placomyces* var. *microsporus;* i, *A. Kauffmanii;* j, *A. approximans;* k, *A. eludens;* l, *A. pocillator;* m, *A. lilaceps;* n, *A. halophilus;* o, *A. brunnescens;* p, *A. comptulus;* q, *A. comptuloides;* r, *A. comptuliformis;* s, *A. auricolor;* t, *A. micromegathus;* u, *A. diminutivus*

New York Botanical Garden, New York City. My collections, 2837 from Washington, 8031 from Oregon, and 9404 from California, appear to be identical with Romell's specimen. Here even more than in *A. subrutilescens* the single or the double character of the annulus is unreliable. In groups of twenty-five to fifty individuals one is often able to select in almost equal numbers specimens with double rings, with single rings, or with rings having a double margin. There is no readily discernible color change to red in either the scales or the flesh of the pileus. The change takes place slowly as the fruiting bodies pass maturity or remain overnight in a laboratory.

AGARICUS HAEMORRHOIDARIUS Schulz. in Kalch. (Fig. 2*g*; Pl. VIII). — The spores drawn were taken from collection 5037, found in a low maple–elm swamp near South Lyons, Michigan. Kalchbrenner's figure illustrates the stature of the Michigan collection very well. The color change in this species is pronounced and apparently reliable. It is in decided contrast to that of *A. silvaticus*. The colors of these two are very similar when dried. When fresh those of *A. silvaticus* are more tawny brown to russet, whereas those of *A. haemorrhoidarius* are vinaceous brown to grayish vinaceous toward the margin. The gill edges of 5037 were covered by sterile clavate cells 28–35 × 8–11 μ. This species has been variously interpreted. A large-spored species is referred here by some (Lange, 14), and such a one was also found among Kauffman's collections. Unfortunately, the material was sent to Kauffman without complete notes. The dried specimens and spores both indicate a relationship to *A. brunnescens*. Kauffman placed in *A. haemorrhoidarius* the small-spored form with the stature of *A. silvaticus*, and I have adhered to this concept. Most of the fruiting bodies in the collection cited above were young, but no yellowish stains developed when any part was bruised. The color change to blood-red was almost instantaneous in my collection. Peck (18) describes the color change of the flesh as slow, and his illustration shows fruiting bodies much grayer than mine. Peck's description and illustration are very suggestive of some forms of *A. placomyces*, but such a relationship has not yet been established.

AGARICUS RUBRIBRUNNESCENS Murr. (Fig. 2*d*). — The spores of the type measure 5–5.5 × 3–3.5 μ. I have not studied fresh speci-

mens. The gill edges are furnished with scattered clavate to subcapitate cheilocystidia, 30–70 × 10–14 μ. Murrill (17) stated that this plant differed from *A. haemorrhoidarius* in having smaller spores and a conspicuously scaly pileus. As it is shown in Plate VIII and as it is usually described by European investigators, the latter species does have a decidedly scaly pileus. A comparison of *d* and *g* in Figure 2 does not show any significant difference in spore size. My measurements of the spores of *A. haemorrhoidarius* are 5–6.5 × 3.5–4 μ. A difference which Murrill did not mention, but which is apparent from his description, is that the color change in *A. rubribrunnescens* is slower and not so bright as that in *A. haemorrhoidarius*. This difference indicates that Murrill's species is closer to *A. silvaticus*. I believe it should be referred to the latter as a synonym. The color change is apparently slightly more pronounced than in the western collections referred to *A. silvaticus*, but evidently the difference is no greater than that frequently encountered in *A. placomyces*.

AGARICUS PLACOMYCES Pk. (Fig. 2*e*; Pl. IX). — The spores of the type measure 4.5–5.5 × 3.5–4 μ. In the fifteen collections which I have examined they are exactly as in the type. Spores of *A. meleagris* J. Schaeffer are illustrated in Figure 2*f* for comparison. There are no appreciable differences. I believe that these two species are the same. *A. placomyces* is rather variable; in some collections the pink color of the gills is very pronounced, in others it is very faint. The very young gills may be either white or grayish. At times the flesh may become decidedly pinkish or even exhibit a slight color change when bruised, but as yet I have not been able to correlate these differences with any other characters, and I regard them as mere variations. Schäffer wrote to Kauffman concerning *A. meleagris*, which Kauffman believed was distinct. In going over Kauffman's notes I found that at that time he was regarding several of his Olympic Mountain collections as a new species, closely related to *A. placomyces*, and it is possible that he considered *A. meleagris* to be identical with them. I have collected the Olympic Mountain form in great abundance in the vicinity of Lake Crescent, Washington, and I believe it is merely a growth form of Peck's species.

AGARICUS PLACOMYCES var. **microsporus** var. nov. (Fig. 2*h*). — Pileus 3–5 cm. latus, convexus, fuligineo-fibrillosus, in centro fuscus;

caro alba, fracta subrosea, inodora, sapore miti; lamellae pallidae, demum incarnatae; stipes 5–7 cm. longus, 6–8 mm. crassus, bulbosus; annulus amplus, duplicatus; sporae 4–5 × 2.5–3 μ. — Specimen typicum legit A. H. Smith n. 8800 prope Smith River, Calif., Nov. 16, 1937; in Herb. Univ. Mich. conservatum.

Pileus 3–5 cm. broad, convex, surface covered by dark gray innate fibrils on a white background, disc blackish, tending to become appressed-fibrillose-scaly near the margin; flesh white, quickly staining reddish when bruised, odor and taste not distinctive; lamellae pallid, becoming pinkish and finally dark fuscous brown; stipe 5–7 cm. long, 6–8 mm. thick, equal above an abrupt flattened bulb, white and silky when young, turning red when bruised and in age sordid brown, annulus ample, pendulous, double, with fuscous areolate patches on the under side near the margin; spores 4–5 × 2.5–3 μ, narrowly ellipsoid, fuscous brown under the microscope; basidia four-spored.

Scattered under spruce in northern California. The two collections which were made were found to be constant in the characters described. The variety is smaller than the species in nearly all its dimensions, and the color change is more pronounced than usual. *A. placomyces* often shows a decided tendency to develop pinkish hues in the flesh of the pileus and in the apex of the stipe, but usually does not change color readily when bruised.

Agaricus Kauffmanii, sp. nov. (Fig. 2*i*). — Pileus 5–7 cm. latus, obtusus demum subexplanatus, sordide luteo-brunneus, fibrillosus; caro alba; odor subaromaticus, sapor mitis; lamellae albae, demum incarnatae, confertae, angustae; stipes 6–9 cm. longus, 5–8 (10) mm. crassus, bulbosus, albidus, glaber; annulus superus, albidus, membranaceus; sporae 4.5–5.5 × 4.5 ± μ. — Specimen typicum legit C. H. Kauffman prope Takhoma Park, Md., July 22, 1919; in Herb. Univ. Mich. conservatum.

Pileus 5–7 cm. broad, at first obtusely ovoid or bullate, then subexpanded or discoid, when young entirely "tawny olive" to "Saccardo's umber," owing to a more or less continuous fibrillose cuticle, becoming appressed-fibrillose-scaly as the pileus expands, the scales "tawny olive," margin not striate; flesh white, unchanging, thin on the margin, somewhat thicker elsewhere, odor when crushed slightly aromatic, taste none; lamellae white in

button stages, becoming "pale Congo pink," pink color persisting a long time, finally becoming chocolate-brown, very crowded, narrow (4 mm. ±), equal, free, occasionally forked at the base, thin, edge entire; stipe 6–9 cm. long, rather slender, 5–8 (10) mm. thick, equal above the small rounded obscure bulb, white, glabrous, stuffed with a firm white pith, apex naked; annulus superior, not broad, single, white, pendant, fragile, evanescent, very slightly floccose below; spores 4.5–5.5 × 4.5 ± μ, very broadly ellipsoid to subglobose; basidia four-spored.

Kauffman found the specimens growing in a grassy area near a sidewalk. The species has the stature of slender specimens of *A. placomyces*, but it is readily distinguished by its almost globose spores. The yellowish brown colors are also distinctive. The annulus was apparently single in Kauffman's collection, but I am not inclined to place much emphasis on that character. Since the dried specimens show no signs of the ochraceous tints assumed by members of the *A. diminutivus* group, they cannot logically be placed there, even though the spores are suggestive.

AGARICUS APPROXIMANS Pk. (Fig. 2*j*). — The spores illustrated were taken from the type. This species, which was collected in company with *A. placomyces* by E. B. Sterling, is, in my estimation, merely an aberrant form of it with an umbonate pileus and with the pink color lacking in the gills. The spores and the colors of the pilei of the two are identical. During seasons when *A. placomyces* is very abundant, as it was around Ann Arbor in 1936 (coll. 4931), large patches of fruiting bodies are often found, some of which contain individuals with little or no pink color in either flesh or gills but which could not otherwise be distinguished from typical material.

AGARICUS ELUDENS Pk. (Fig. 2*k*). — The spores illustrated were taken from the type and measured 5–6 × 3.5–4 μ. Peck gave the measurements of the spores as 5–7 × 4–5 μ, and Murrill (17) apparently copied them. Peck's figures are very suggestive of *A. haemorrhoidarius*, as is his description also. In my notes on the type I described it as similar to *A. silvaticus* in color, but slightly smaller in stature. The spores, the color of the pileus, and the changing flesh seem to me to be sufficient reason for reducing *A. eludens* to synonymy with *A. haemorrhoidarius*. The stature is suggestive of *A. sanguinarius* Karst., but in Peck's

description no mention is made of the stipe of young specimens becoming yellowish when bruised. In their accounts of *A. sanguinarius* Lange (15) and Rea (20) both note this character.

AGARICUS POCILLATOR Murr. (Fig. 2*l*). — The illustration was made from spores of type material sent to me by Murrill. The specimen was immature, and few dark-colored spores could be found. They measured 4.5 5.5 × 3–3.5 μ; the basidia were four-spored. To judge from the specimen I have examined, the species is one of the forms of *A. placomyces*.

AGARICUS BRUNNESCENS AND CLOSELY RELATED SPECIES

AGARICUS HALOPHILUS Pk. (Fig. 2*n*). — The spores of the type measure 6–7 (8) × 5–6 μ. The dried specimens resemble dried material of *A. Rodmani* in stature and color, but the delicate annulus places it next to *A. campestris*. Aside from the changing flesh, it in no way resembles species of the *A. silvaticus* group; it differs from *A. haemorrhoidarius* in its larger spores, disagreeable odor, squatty stature, and pale color when dried. It is doubtful whether the report of this species from Washington by Hotson and Stuntz is correct. They (9) describe the pileus as having broad, appressed brown scales, odor and taste not marked, and the annulus as pendant, thick, persistent, and feltlike. All these characters indicate that the Washington collection is closer to *A. vaporarius* Vitt. *sensu* Schaeffer & Moeller (22).

AGARICUS BRUNNESCENS Pk. (Fig. 2*o*). — The spores of the type measure 6–7 (8) × 5–6 μ. Stewart (24) reported on the growth of a species, from spawn, which Kauffman determined as being very near *A. brunnescens*. Stewart's specimens are preserved in the University of Michigan Herbarium. The dried fruiting bodies as well as his description of them indicate that the species is more properly classified as *A. vaporarius*. The dark reddish brown conspicuously scaly pileus, peronate stipe, double, thick, felty annulus, the flesh, which changes to reddish when cut or bruised, and the spores all support this conclusion. Schäffer and Möller (22) comment on forms of the species in culture in Berlin, and Krieger (13) has noted that *Psalliota villatica* (a synonym of *A. vaporarius*) is grown by at least one producer in the United States. It is apparent from Schäffer's comments that the species

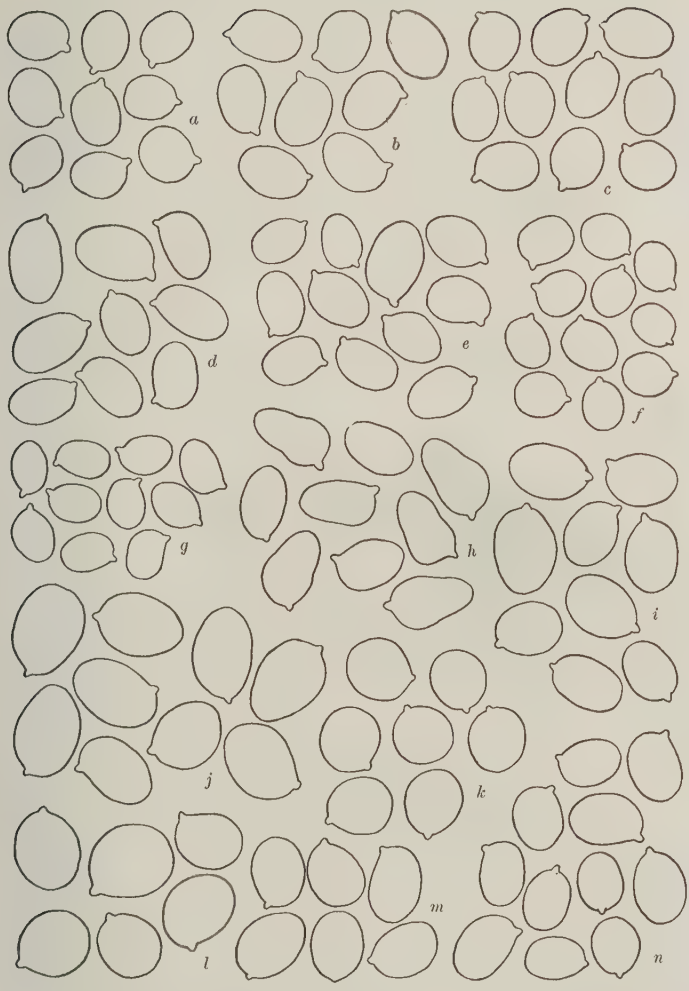

FIG. 3. a, *A. Rodmani;* b, *A. Pattersonae;* c, *A. rutilescens;* d, *A. californicus;* e, *A. subnitens;* f, *A. bivelatus;* g, *A. cervinifolius;* h, *A. campestris;* i, *A. solidipes;* j, *A. argentatus;* k, *A. pilosporus;* l, *A. chlamydopus;* m, *A. praerimosus;* n, *A. Sterlingii*

is recognizable both in the wild state and under cultivation by the characters given above. Peck described the pileus of *A. brunnescens* as fibrillose, sometimes slightly squamose and silvery whitish when very young, becoming avellaneous to bay or brown. These characters at once separate his species from *A. vaporarius*. The description and illustration given in *Icones Farlowianae* (5) should be considered authentic for *A. brunnescens*. A comparison of it with Stewart's excellent photographs and description will clear up any questions regarding the two.

Agaricus Sterlingii Pk. (Fig. 3*n*). — The spores of the type measure 6–7.5 (8) × 4.5–5.5 (6) μ. An examination of the type showed the annulus to be thick and double. The spores and stature as well as the color of the dried specimens strongly indicate a similarity to *A. brunnescens*. The more conspicuous scales, however, together with the lack of pink colors in the gills, might distinguish it.

Agaricus rutilescens Pk. (Fig. 3*c*). — The spores of the type are quite variable in size, measuring (5.5) 6–7 (8) × 4–5.5 μ. In the majority of Kauffman's collections from the Rocky Mountains (11) they measure 5–6.5 × 4–5.5 μ. In one, however, they are 7–9 × 5–6 μ. The type consists of small or badly weathered specimens in which the pilei are areolate and not darker than ochraceous tawny. The annulus was missing on many of the specimens, but when present it appeared to be of the same type as that of *A. Rodmani*. The upper limb was rather broad, and the lower one flared only slightly. Kauffman described the annulus in his specimens as simple. It is impossible to be certain that Kauffman examined the type before publishing his comments, and it is doubtful whether his account (11) is based on a single species. Because of this it seems advisable to adhere to the original description and to observations on the type when interpreting Peck's species.

Agaricus Rodmani Pk. (Fig. 3*a*). — The spores of the type are subglobose and measure 5–6 × 4–5 μ. Hotson and Stuntz (9), who reported this species from Washington, give the measurements of the spores as 6–7.5 (8) × 4–5 μ and describe them as ellipsoid rather than subglobose. In all the material I have examined from eastern United States the spores have been exactly as in the type. Kauffman (10) published slightly different measurements, but

the spores of his specimens agree with those of the type. Hotson and Stuntz noted that the annuli of the Washington specimens were poorly developed. This is an added discrepancy. Schäffer and Möller (22) consider Peck's species synonymous with *A. edulis* of Europe. From the illustrations published by Herrfurth (8) under the name *Chitonia edulis* there can be little doubt that they are the same. The only question remaining is in regard to the valid name. This is a delicate problem in itself and involves other names which were used as specific epithets before *A. edulis* was raised to that rank. Since the species has been commonly known in North America under the name Peck gave it, I see no advantage in substituting a name of doubtful standing. Atkinson's excellent illustrations and study (1) seem to have been overlooked by most European investigators.

Agaricus Pattersonae Pk. (Fig. 3*b*; Pl. X). — The spores of the type measure 6–7 × 4–4.5 μ. The photograph shown in Plate X accompanies the type. The annulus and the decidedly scaly pileus are the most distinctive features of the species.

Agaricus californicus Pk. (Fig. 3*d*). — The spores of the type measure 7–9 (10) × 4–5 (6) μ. A small number of even larger spores are also present. The gill edges are furnished with clavate thin-walled cheilocystidia which measure 26–34 × 7–12 μ. The annulus has a thick marginal band with scales on the under side. To judge from the dried material, this is a rather long-stemmed species similar in stature to *A. silvaticus*. The large spores at once distinguish it, however.

Agaricus bivelatus Pk. (Fig. 3*f*). — The spores of the type measure 4–5 × 3.5–4 μ and are subglobose. In stature the type resembles a robust *A. diminutivus*, but does not belong in its group. The double annulus is well preserved. The spores are similar to those of *A. Kauffmanii*, but the colors of the pilei should separate the two readily.

Agaricus comptulus and closely related species

Agaricus comptulus Fr. (Fig. 2*p*). — The drawings of the spores were made from material determined by Bresadola and deposited at the New York Botanical Garden. They measure 4–4.5 × 3.5 ± μ. This species, *A. micromegathus* Pk. (Fig. 2*t*), *A. auricolor* Krieger (Fig. 2*s*), *A. comptuliformis* Murr. (Fig. 2*r*), *A. com-*

ptuloides Murr. (Fig. 2*q*), and *A. diminutivus* Pk. (Fig. 2*u*) all have spores which are practically identical. All the illustrations of the spores of American species given here are drawn from type material. In *A. diminutivus* the stipe may be smooth but peronate below the annulus or the sheath may be broken up into fibrillose patches. Peck's specimens show both conditions well. The type of *A. comptuloides* appears to be identical with the western form of *A. diminutivus,* which I have collected in large quantities in the Cascade Mountains of Oregon. Murrill (17) states that *A. comptuliformis* differs from *A. comptulus* in having larger and darker spores, but a comparison of the figures of both does not bear out the statement. The bright yellow color of Murrill's species should distinguish it, but immediately suggests identity with *A. auricolor;* see Coker (4). Murrill, however, recognizes the latter in Florida. It is more robust, and the taste is decidedly amygdaline. In general, species concepts in this group are very unsatisfactory at present in both North America and Europe, and are sadly in need of a critical study based on an examination of fresh specimens.

Agaricus lilaceps Zeller (Fig. 2*m*). — This is apparently the largest species in the section. The annulus, the color change to yellow or tawny yellow when bruised or on drying, the spores, and pale pinkish tints all indicate its place in this group. It is at once distinguished from the other species by its slightly larger spores, 5–6 × 4–4.5 μ. The drawings were made from type material.

Agaricus campestris and closely related species

Agaricus subnitens Pk. (Fig. 3*e*). — The spores measure (5) 6.5–8 (9) × 4.5–5 (6) μ in the type. The annulus is fibrillose on the under side, but has an upper and a lower marginal limb. In the dried material it is paler than the pileus, and I doubt the value of the color of the ring as a distinguishing character.

Agaricus cervinifolius Zeller (Fig. 3*g*). — The spores of the type are as Zeller described them and they remind one of those of species grouped around *A. silvaticus,* to which, however, it is not at all similar in other characters.

Agaricus campestris Fr. (Fig. 3*h*; Fig. 4*r–t*). — Figure 4*q* is of the cultivated variety, which clearly is distinct from the wild

variety. The spores figured in 3*h* were from a fruiting body collected in the same pasture on the same day that those shown in Figure 4 *r*, *s* were found. The ones shown in Figure 4*t* were taken from a California collection. The spores in this species are apparently more variable than those in other species of the genus. As yet, however, I have not had the opportunity to study a large series of collections in order to determine whether or not the somewhat ventricose spores of Figure 3*h* represent a distinct form. In view of the variation in only the one pileus, I doubt whether they do.

AGARICUS SOLIDIPES Pk. (Fig. 3*i*). — The spores of the type measure 7–9 × 5–6 μ. In some of its pilei the surface is broken into scales, whereas in others it is areolate. The annulus is single, and the stature is that of *A. campestris*. I have received numerous collections of it from central Texas, where it is often very abundant in both spring and fall. In that region it apparently takes the place of *A. campestris*.

AGARICUS ARGENTATUS Pk. (Fig. 3*j*). — The spores of the type measure 8–10 × 5.5–7 μ and are broadly ellipsoid. The apices are often slightly flattened, but no hyaline germ pore was visible. The dark-colored young lamellae, the large spores, and the grayish pileus should be distinctive.

AGARICUS PILOSPORUS Pk. (Fig. 3*k*). — The spores of the type measure 6–7 (8) × 5–6.5 μ. It is well preserved and is similar to *A. arvensis* in stature. The dried pilei are of a pale cream color. The annulus appears to be single, as in *A. campestris*. The scales on the stipe are due to the broken cuticle and not to a ruptured sheath. The species appears very distinct.

AGARICUS CHLAMYDOPUS Pk. (Fig. 3*l*). — The spores of the type measure 8–9 (10) × 6–7.5 (8) μ. The pileus dried a dead white and the gills black. The ventricose stipe is sheathed by a white veil, which terminates in a cup, as described by Peck. The combination of chocolate-colored young gills (as described by Peck), the veil characters, and the large spores make it very distinct.

TROPICAL SPECIES

Tropical Species. — Figure 4 *b*-*n* illustrates spores of tropical American species described by Murrill. All the drawings are from type material. In this figure *b* represents the spores of *A. angustifolius;*

FIG. 4. a, *A. echinatus;* b, *A. angustifolius;* c, *A. cinchonensis;* d, *A. Earlei;* e, *A. herradurensis;* f, *A. Hornei;* g, *A. Johnstoni;* h, *A. ochraccidiscus;* i, *A. praemagnus;* j, *A. Schafferi;* k, *A. subpratensis;* l, *A. subsilvicola;* m, *A. venus;* n, *A. xuchilensis;* o, *A. alabamensis;* p, *A. praemagniceps;* q, *A. campestris* (cultivated form); r–t, *A. campestris,* wild form

c, of *A. cinchonensis; d*, of *A. Earlei; e*, of *A. herradurensis; f*, of *A. Hornei; g*, of *A. Johnstoni; h*, of *A. ochraceidiscus; i*, of *A. praemagnus; j*, of *A. Schafferi; k*, of *A. subpratensis; l*, of *A. subsilvicola; m*, of *A. venus*, and *n*, of *A. xuchilensis*.

The spores of *A. angustifolius* resemble those of *A. echinatus* in size and shape, but these are apparently the only similarities between the two. In *A. cinchonensis* the spores measure 4–5.5 × 2.5–3 μ, and cheilocystidia, which measure 28–34 × 9–13 μ, are abundant. The spores of *A. Earlei* and *A. herradurensis* measure 4.5–5 × 3.5–4 μ. The annulus in the latter species is described as almost basal, whereas in the former it is said to be apical. In all other respects they lack distinguishing characters. The spores of *A. Hornei* measure 5–6.5 × 4–4.5 μ. *A. Johnstoni* is characterized by exceptionally small spores, 4–4.5 × 2.5 ± μ, which are pale chocolate-brown under the microscope.

In *A. ochraceidiscus* the spores measure 4.5–5 × 3–3.5 μ; the cheilocystidia, 26–35 × 7–12 μ. *A. praemagnus* has larger spores, 6–7 (8) × 4–4.5 μ, and cheilocystidia which resemble sterile basidia. The thick flesh is characteristic even in the dried condition. *A. Schafferi* resembles *A. augustus* in the ornamentation of the pileus, but has much smaller spores, 5–6.5 × 4–4.5 μ, which are very dark chocolate-brown under the microscope. The spores of *A. subpratensis* are of two distinct ranges in the type. The larger individuals measure 8–10 × 5–6 μ and are not so numerous as the smaller ones, which measure 6–7.5 × 5–6.5 μ. The latter measurements should be considered typical. When dry the flesh of the pileus is thick and almost powdery or punklike in consistency. The spores of *A. subsilvicola* separate it from *A. silvicola*. They measure 5–6 × 3–3.5 μ. *A. venus* has spores 5–6.5 × 3–3.5 μ and cheilocystidia 15–20 × 9–12 μ, which are thin-walled. *A. xuchilensis* has spores 5–6 × 2.5–3 μ. The type is in very poor condition.

MISCELLANEOUS SPECIES

AGARICUS PRAERIMOSUS Pk. (Fig. 3*m*). — The spores of the type measure 6.5–8 × 5–6 μ. The cheilocystidia, which measure 30–35 × 10–12 μ, are thin-walled and clavate. The annulus is double.

AGARICUS ECHINATUS Fr. (Fig. 4*a*). — I have collected this species

in New York, Michigan, and California. The drawings of the spores are of collection 10982. I have studied Kauffman's type of *Hypholoma vinosum*, but am unable to find differences which separate it as a species from *A. echinatus*. The gills are typically free, but at times may reach the stipe and apparently become spuriously attached. The scales on the pileus are powdery and conic in perfectly developed specimens. One seldom finds them in such condition, however, because the expansion of the pileus usually reduces them to powder. Specimens which I collected in 1929 and which Kauffman determined as *H. vinosum* were similar in color to *A. echinatus*. The stipe is "Prussian red" to "Indian red" beneath the umber powdery coating; when it is squeezed, a small amount of reddish sap is exuded.

Agaricus praemagniceps Murr. (Fig. 4*p*). — Through the courtesy of Dr. W. A. Murrill authentic material of this species was obtained for drawings of the spores. They measure 5–6.5 × 3.5–4 ± μ. Hyaline lactiferous hyphae are common in the pileus and the gill trama. The basidia are four-spored.

Agaricus alabamensis Murr. (Fig. 4*o*). — The spores of the type measure (5.5)6–7 × 4–4.5 μ, and are a very dark chocolate-brown under the microscope.

Agaricus ciscoensis, sp. nov. (Fig. 1*o*). — Pileus 2–3.5 (4) cm. latus, convexus, demum planus, siccus, subfibrillosus, brunneus; lamellae confertae, latae, incarnatae demum fuscae; stipes 3–5 cm. longus, 3–5 (6) mm. crassus, valde radicatus; annulus superus tenuis, albidus, fugax; sporae 7–8 × 4.5–5 μ; basidia tetraspora. Specimen typicum legit E. A. Smith n. 1 prope Cisco, Texas, Sept. 10, 1935; in Herb. Univ. Mich. conservatum.

Pileus 2–3.5 (4) cm. broad, convex, becoming plane, surface dry and slightly silky-fibrillose, dull brown (near "cinnamon-brown"), fading somewhat on drying, disc darker owing to a denser fibrillose covering; flesh thin, whitish, sordid reddish brown in age, odor and taste not recorded; lamellae close, free but approaching the stipe, moderately broad, pink when young, finally dark chocolate-brown, edges even; stipe 3–5 cm. long, 3–5 (6) mm. thick, tapering slightly above a somewhat bulbous base, usually with a long pseudorhiza penetrating into the soil from the base of the bulb, surface smooth and silky above and below the superior annulus, whitish but becoming sordid vinaceous

brown or grayish brown over all in age or upon drying (in one the stipe stained reddish when handled), stuffed, becoming hollow; annulus single, very narrow (1.5–2.5 mm.), whitish or pallid, silky above, somewhat fibrillose below, thin, sometimes evanescent; cheilocystidia basidia-like and not otherwise differentiated; basidia four-spored; spores 7–8 × 4.5–5 μ, smooth, ellipsoid, dark chocolate-brown under the microscope.

Scattered on soil under live oaks. Known only from the type locality. In many respects it reminds one of *A. diminutivus*, but the radicating stipe, the larger spores, and the brown pileus at once distinguish it. The pseudorhiza of this species is well differentiated. Owing to the difficulties of digging it out of the hard soil its point of origin was not determined.

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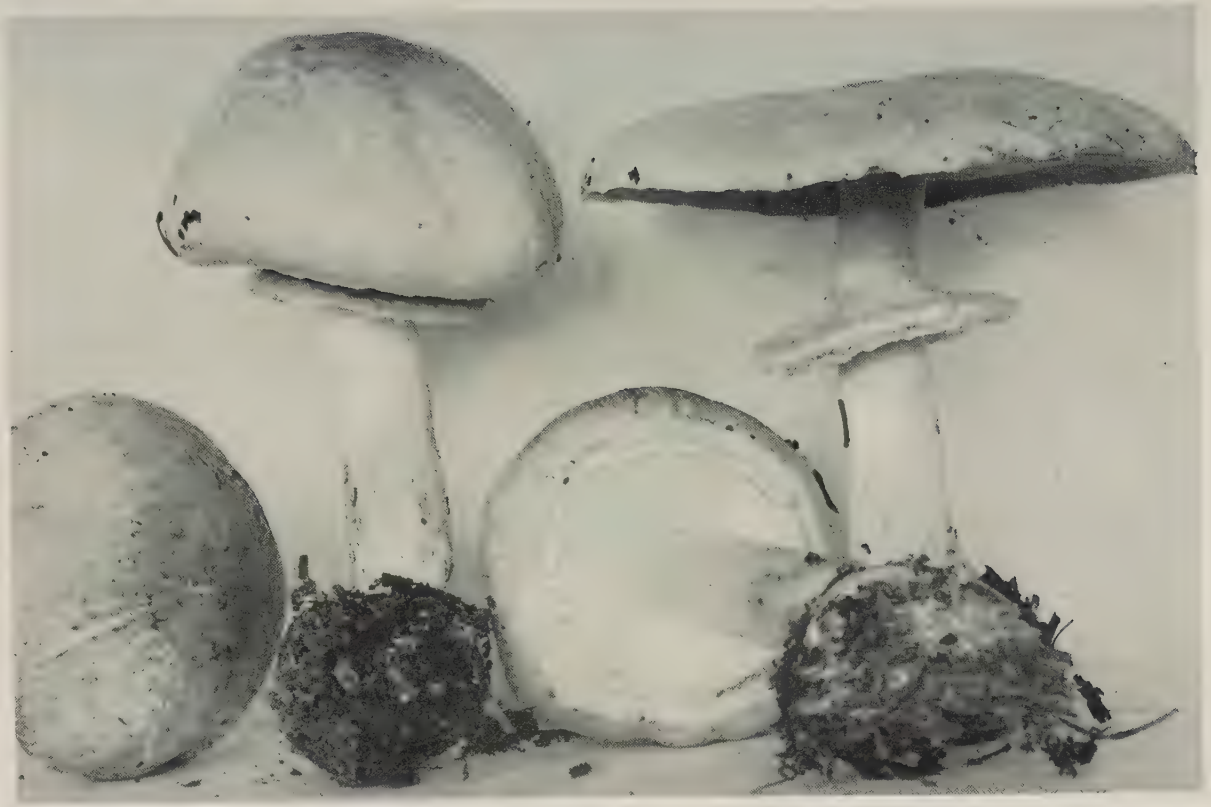
Agaricus crocodilinus Murr. × 1

Agaricus crocodilinus Murr. × 1

Agaricus subrutilescens (Kauff.) Hotson & Stuntz. × 1



Agaricus glaber Zeller. × 1

Agaricus glaber Zeller. × 1

Agaricus silvaticus Fr., young specimens. × 1

Agaricus silvaticus Fr., older specimens. × 1

Agaricus haemorrhoidarius Schulz. in Kalch. × 1

Agaricus placomyces Pk. × 1

Agaricus Pattersonae Pk. × 1

MORPHOLOGICAL STUDIES ON THE SEED OF SNAPDRAGON (*ANTIRRHINUM MAJUS* L.)

EDWARD F. WOODCOCK

A STUDY of the literature on *Antirrhinum majus* L. gives very little information in regard to the morphology of the seed. Much has been written about its culture, genetics, and pathology. Propach (2), in his cytological studies of this plant, finds that the embryo sac develops in the normal manner. Klemm (1) states that the anatropous ovules are borne on an axile placenta. His figure of the longitudinal section of a single ovule shows the micropyle and thick integument, but no detail of the embryo sac. This paper deals with the seed morphology in *Antirrhinum majus* L., a member of the Scrophulariaceae.

DESCRIPTION AND DISCUSSION OF THE MORPHOLOGY OF THE SEED

The stages of seed development were studied by means of microtome sections cut 10 microns thick and stained with Delafield's haematoxylin.

The two-loculed compound pistil has axile placentation and many ovules in each locule. The placental region is slightly enlarged and projects into each locule. The anatropous ovules are smooth when young, before fertilization occurs (Pl. I; Pl. II, Fig. 1). Each ovule is elongated and rounded, and in cross section is circular in outline.

There is only one integument, and it is several cells in thickness (Pl. II, Fig. 1). The epidermis consists of flattened cells, each of which has very little convexity in its outer wall. The cells which surround the micropylar canal are somewhat elongated. At the time of fertilization the young embryo sac is surrounded by a one-layered nucellus made up of cells, each of which has a centrally placed nucleus and a dense cytoplasm. These cells persist during most of the development of the seed. The embryo sac is circular in cross section, elongated, and narrowed in its chalazal region. The free

part of the funiculus is so short that the micropylar opening is almost in contact with the wall of the locule.

As growth proceeds in the ovule it enlarges rapidly, and marked changes occur as the fertilized egg divides to form a three-celled filamentous suspensor and a two-celled embryo (Pl. II, Fig. 6). The embryo sac increases and becomes almost completely filled with cellular endosperm, in which no starch grains occur. The cells in the central region of the endosperm tissue are larger and more vacuolated than those in the peripheral region, where the outer cells form a rather distinct layer. In the narrowed chalazal portion of the embryo sac the endosperm is in the free nuclear condition. The cells of the nucellus are somewhat flattened because of the pressure of the cellular endosperm. At intervals on the surface of the ovule there are interconnecting ridges (Pl. II, Fig. 2), which have arisen by the bulging outward of the outer wall of adjacent epidermal cells. The height of the ridges varies in different parts of the ovule, and the radial length of the individual cells which form each ridge is not always the same. The outer wall of the epidermal cells between the ridges is distinctly convex. In the cell cavity of the epidermal cells there is a dense granular deposit next to the outer wall of the cell.

The suspensor undergoes no changes as the embryo continues its development. Numerous nuclear and cellular divisions occur in the embryo to produce a many-celled spherical structure (Pl. II, Fig. 4; Pl. III, Fig. 7). While these changes are taking place in the embryo the extent of the endosperm tissue increases and the cells of the nucellus layer and integument become somewhat flattened (Pl. I; Pl. II, Fig. 3). The cells of the outer layer of the endosperm are square in radial section, and smaller than those in the adjacent endosperm. The few starch grains which appear in the endosperm vary in size. Those in the outer layer of cells are smaller than those in other parts (Pl. II, Fig. 5) of the endosperm.

As the embryo develops further it forms two cotyledons, which are semicircular in cross section and about one third as long as the entire embryo (Pl. III, Fig. 9). No well-marked plumule develops at the base of the cotyledons. The embryo is straight, centrally placed, and located in a cavity in the endosperm produced by the absorption of the cellular endosperm formed earlier in the seed development. In the fairly well marked layer of cells forming the periphery of the cellular endosperm the number and size of the starch grains is less

than in the adjacent endosperm tissue. Immediately surrounding the cavity in which the embryo is located there is a region of somewhat compressed endosperm cells in which no starch occurs. The layer of nucellus cells is much compressed, and the cells of the integument are somewhat flattened. At this stage of development the young seed is light brown, and the outer wall of the epidermal cells and the common wall between the cells which form the ridges are much thickened and pitted.

There occur but few other changes in the embryo and endosperm as the seed matures. In the mature stage (Pl. I; Pl. III, Figs. 10, 12) the starch-free and the starchy endosperm are quite distinct from each other. All the cells of the nucellus layer and the integument, except the epidermal layer of the latter, have been absorbed by the endosperm, and in the mature seed the seed coat consists of an epidermal layer of cells separated from the endosperm by the crushed remains of the nucellus and inner cells of the integument. The granules in the lumen of the epidermal cells and the pits in the walls of these cells are very evident in a cross section of the seed coat and adjacent tissue (Pl. III, Fig. 11). The outer tangential wall of each cell of the epidermal layer of the endosperm is thickened and convex. Numerous spherical starch grains, which vary in size, are scattered through the lumen of the endosperm cells (Pl. III, Fig. 8).

SUMMARY

The ovule of *Antirrhinum majus* L. is anatropous and somewhat elongated, and appears almost circular in outline when cut in cross section. As the seed matures the cellular endosperm increases, and the nucellus, one layer of cells in thickness, becomes disorganized. All the cells of the integument, except the epidermal layer, also are crushed. As a result, the seed coat of the mature seed consists almost entirely of a single layer of cells, some with hairlike outgrowths, which are arranged in interconnected ridges. The embryo is a typical dicot type, straight and centrally placed in the starchy endosperm.

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EXPLANATION OF PLATE I

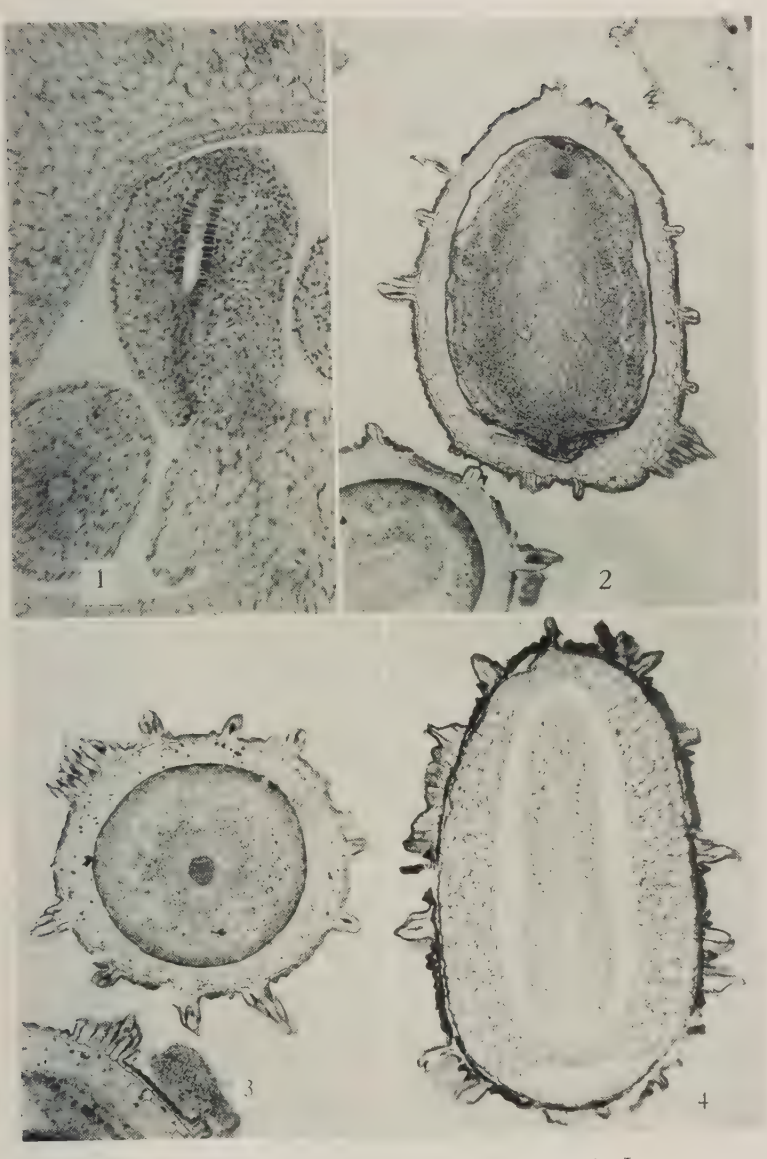
Stages in development of seed

Fig. 1. Longitudinal and cross section of ovule. × 79

Fig. 2. Longitudinal section of ovule, with embryo in spherical condition. × 44

Fig. 3. Cross section of ovule shown in Figure 2. The embryo is evident in the center of the endosperm. × 33

Fig. 4. Longitudinal section of mature seed. The seed coat consists almost entirely of the epidermis of the integument. × 35



Stages in development of seed of *Antirrhinum majus* L.

NOTE

Seed of *Antirrhinum majus* L.

All figures drawn with the aid of camera lucida. The following abbreviations are used: CO, cotyledons; E, embryo; EN, endosperm; EP, epidermis; ES, embryo sac; F, funiculus; G, granules; H, hypocotyl; M, micropyle; N, nucleus; NU, nucellus; R, radicle; RE, remains of nucellus and integument; S, suspensor; SC, seed coat; ST, starch; T, integument

EXPLANATION OF PLATE II

FIG. 1. Longitudinal section of young ovule, with embryo sac surrounded by nucellus, one layer of cells in thickness. × 207

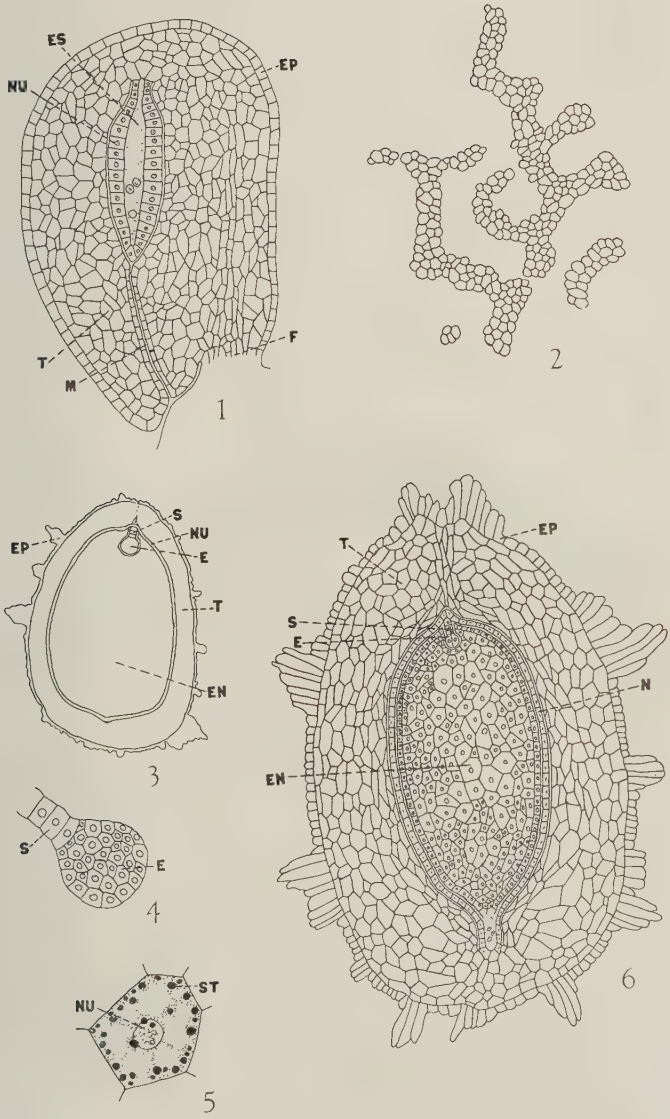
FIG. 2. Cross section of ridges. × 75

FIG. 3. Longitudinal section through ovule at the stage when the embryo is in the spherical condition and the endosperm in the cellular condition. × 40

FIG. 4. Detail of embryo and suspensor shown in Figure 3. × 207

FIG. 5. Endosperm cell from stage shown in Figure 3. × 430

FIG. 6. Longitudinal section through young ovule, showing cellular detail. Embryo in the two-celled stage. Endosperm differentiated into inner, large-celled region and outer, small-celled epidermal region. Some of the epidermal cells of the integument enlarged to form ridges shown in Figure 2. Nucellus layer compressed. No starch present. × 75



Seed of *Antirrhinum majus* L.

EXPLANATION OF PLATE III

FIG. 7. Cross section of ovule shown in Plate II, Figure 3. × 40

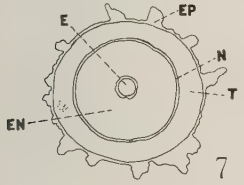
FIG. 8. Cellular detail of outer portion of endosperm in mature seed. Starch grains and cells are smaller in epidermal layer. × 430

FIG. 9. Longitudinal section of nearly mature seed. × 40

FIG. 10. Cross section of mature seed; the section passes through the cotyledons. × 40

FIG. 11. Cross section of outer portion of mature seed. The epidermis of the integument, with its numerous brown granules, is separated from the endosperm by the compressed remains of the nucellus and the inner cells of the integument. × 207

FIG. 12. Longitudinal section of mature seed. The seed coat consists of the epidermis of the integument and the broken-down cells of the nucellus and integument. The endosperm next to the embryo has no starch grains. The amount of starch in the outer portion of the endosperm region is shown in Figure 8. × 75



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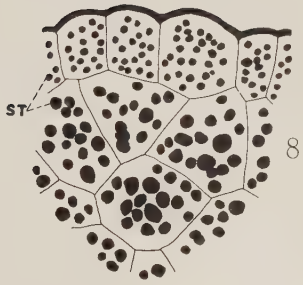

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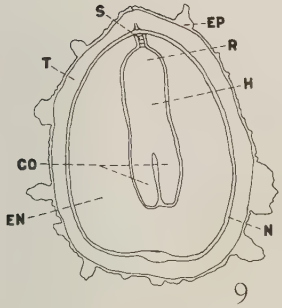

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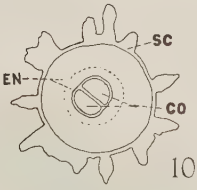

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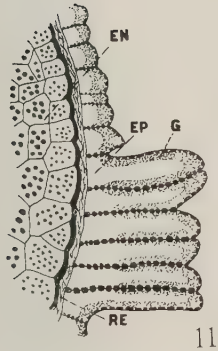

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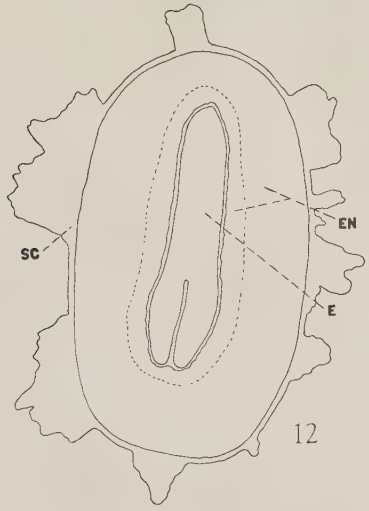

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Seed of *Antirrhinum majus* L.

FORESTRY

SOME RESUPINATE POLYPORES FROM THE REGION OF THE GREAT LAKES. XI

DOW V. BAXTER

IN THE preparation of these monographic studies of the resupinate polypores of the North American continent it has been the object to supplement the material found in various American and European herbaria by records obtained directly in the field. In addition to specimens gathered in the United States and in certain Canadian provinces, collections have been made on seven expeditions to Alaska, the Yukon, and the Northwest Territories.

Descriptions of ten resupinate polypores are presented in this paper.[1] **Poria ferox** is described as a new species. In addition, the characteristics of resupinate polypores in culture are discussed, and the growth features of these polypores are presented in Table I (p. 146).

Trametes rigida Berk. and Mont. 1849. Not *Polyporus rigidus* Lei. 1844

Polystictus extensus Cooke in Sacc., Syll. Fung., 6 : 244. 1888.
Polystictus rigens Sacc. & Cub. in Sacc., Syll. Fung., 6 : 274. 1888.
Coriolopsis rigida (Berk. & Mont.) Murr., North American Flora, 9 : 75. 1908.

(Plates I–III)

Type, cotypes, and important specimens:

Trametes rigida Berk. & Mont., Bahia, Brazil. Type. Herb. of Bresadola, Stockholm.

[1] Throughout the work upon these monographs I am indebted to many individuals and institutions for suggestions, help, and privileges extended to me. My appreciation is expressed particularly to the men who have accompanied me on my seven expeditions to Alaska, the Yukon Territory, and the Northwest Territories. Much credit is due them for aiding in the collection and care of the specimens and for living at times under rather difficult circumstances. I am under obligation to Professors T. G. Halle and Gunnar Samuelson, of the Naturhistoriska Riksmuséet in Stockholm, with whom I have had the pleasure of association. Thanks are rendered several American institutions and scholars also. To the authorities at the New York Botanical Garden, to Dr. W. H. Long, Albuquerque, New Mexico, to the staff of the Division of Pathological and Mycological Collections of the United States Department of Agriculture, and to the staff of the Division of Forest Pathology of the same department I am especially indebted. Dr. Ross Davidson, Dr. W. A. Campbell, and Dr. C. Audrey Richards of that office kindly furnished certain cultures of fungi which were used in this study.

average 2–4, and are mostly 3–4, to a mm. Overholts (12) states that hyphal pegs in *T. serpens* are visible under a hand lens.

Since resupinate specimens of *Fomes fraxinophilus* are corky, white or whitish, and possess a white to light-brown context, and since the mouths of the tubes average 2-3 to a mm., some difficulty may be encountered in separating it from members of the group under discussion. The spores of *F. fraxinophilus* are ellipsoid to ovoid, 6–8 × 5–6 μ, and not cylindric-ellipsoid as in the species of Trametes discussed.

Cultures. — Isolated from *Quercus Shumardii*, Fort White, Florida, and from *Nyssa biflora*, Stark, Florida. The mycelium from both isolates exhibits a concentric to radiating type of growth in agar cultures, and the isolates are similar in their growth habits on wood blocks. The white to "cartridge-buff" or "cream-buff" mycelium covers hardwood blocks (red gum), but merely radiates in strands or fanlike growth over white-pine blocks and does not cover such wood in one-year-old cultures. No pore formation has occurred.

Since fruiting bodies of *Trametes rigida* and *T. Morgani* have been confused, their cultures should be compared. An isolate of *T. Morgani* from *Quercus sp.* likewise is inhibited in its growth on white-pine blocks, but the radiating mycelium does not spread over the wood in coarse strands as does that of *T. rigida.* The mycelium, furthermore, is whitish, or "light buff" and does not form the thick chamois-like covering on hardwood blocks that is characteristic of the clay-colored ("cartridge-buff") fungous growth of *T. rigida.*

Habitat. — *Acer floridanum, Carya sp., Fraxinus americana, F. nigra, Liquidambar styraciflua, Nyssa aquatica, N. biflora, Pinus echinata, Populus sp., Quercus laurifolia, Q. Shumardii, Salix nigra.*

Distribution. — Alabama, Florida, Georgia, Kentucky, Louisiana, North Carolina, Ohio, Pennsylvania, South Carolina, Tennessee, Texas.

Occurrence. — This tropical plant is common in parts of the southern United States on stumps and prostrate logs of the low wet woods, swamps, and bayous.

Poria ferox Long & Baxter, sp. nov.

(Plate IV)

Type:

Trametes ferox on *Juniperus virginiana*, Casteel, Ozark National Forest. W. H. Long. U. S. Forest and Timber Disease Surv. 12150. 1912.

Fructificatio annua vel perennis, coriacea, plus minusve 15 cm. effusa irregulariter in ligno carbonario, inseparabilis, 3 mm. crassa; margo primum sterilis, crassus, rotundatus, undulatus, tomentosus, 1 mm. latus, pallide ochraceus vel ochraceo-cinnamomeus, aetate fertilis; subiculum pallide ochraceum, 0.3 mm. crassum; tubi plerumque 0.5–1 mm. longi, interdum in stratis sed plerumque obscure stratosi; aperturae ochraceae, siccitate aliquando pallide ochraceae vel eae apud marginem fructificationis nigrescentes, $\frac{1}{2}$–$\frac{1}{5}$ mm. crassae; basidia 4-spora, 10–14 × 5–7 μ; sporae hyalinae, 5–6 × 3 μ; hyphae raro furcatae, 3–4 (5) μ, plerumque non incrustatae; anastomoses absunt.

Fructification annual or perennial, effused for 15 cm. or more in irregular patches on charred or old wood, inseparable, up to 3 mm. thick; margin at first sterile, thick, rounded, undulating, tomentose, up to 1 mm. wide, "cartridge-buff" to "cinnamon-buff," becoming fertile with age; subiculum "cartridge-buff," up to 0.3 mm. thick; tubes mostly 0.5–1 mm. long, sometimes stratose, but indistinctly so; mouths "cartridge-buff," "pinkish buff," sometimes drying to "clay-color" or those at margin of fructification becoming blackish, 2–5, mostly over 3, to a mm.; basidia 4-spored, 10–14 × 5–7 μ; spores hyaline, 5–6 × 3 μ; hyphae seldom branched, 3–4 (5) μ, mostly not encrusted; clamp connections not present.

Allied species. — *Poria ferox* is allied to *Polyporus unitus* (*Poria medulla-panis*), from which it differs in that its hyphae are seldom branched. The difference in spore size is also to be stressed. The spores of *Pol. unitus* are mostly ellipsoidal, 4 × 5 μ, whereas those of *P. ferox* are generally oblong, 5–6 × 3 μ. *Pol. unitus*, so far as is known, occurs only on frondose species, but *P. ferox* is found on juniper. Both size and character of the dissepiments of the pore mouths in *P. ferox* suggest *Pol. unitus* (*P. medulla-panis*). The blackish tubes at the margin of the fructification of *P. ferox* and the small size of the pore mouths in many specimens

will distinguish it from *T. serialis*, which, like it, is also found on conifers. In such collections of *P. ferox* the mouths average 5–6 to a mm., but in *T. serialis* only 3 to a mm. The spores of *P. ferox* are slightly shorter, 3 × 5–6 μ, than those of *T. serialis*, 2–4 × 7–10 μ.

Habitat. — *Juniperus monosperma, J. virginiana.*

Distribution. — Arkansas, New Mexico.

Decay. — This fungus has been found several times by Dr. Long on dead timber, fallen or standing. The decay is a brown cubical rot. Thick mats of whitish mycelium form between the checks in the wood and remind one of those in wood decayed by *Fomes pinicola*. The cubes are characteristically smaller than those observed in most rots of this nature. Many of the cubes are only 1–2 mm. in diameter.

Poria versipora[2] (Pers.) Romell in Svensk Bot. Tidsk., 19. 1926

Polyporus versiporus Pers., Myc. Eur., 2 : 105, *p. p.;* Romell in Svensk Bot. Tidsk., 20 : 19. 1926.
Hydnum paradoxum (Schrad.) Fr., Syst. Myc., 1 : 424. 1821.
Hydnum pseudo-boletus DC., Fr., Syst. Myc., 1 : 424. 1821.
Irpex paradoxus (Schrad.) Fr., Fr. Ep., 522. 1838; Hym. Eur., 612. 1874.
Hydnum obliquum (Schrad.) Fr., Syst. Myc., 1 : 424. 1821.
Irpex obliquus (Schrad.) Fr., El., 147. 1828; Hym. Eur., 622. 1874.
Polyporus radula Pers., Myc. Eur., 2 : 107. 1825 (non *Polyporus radula* Pers. ex Fr. 1821; non Bres., Bourd. et Galz.).
Irpex deformis Fr., El., 147. 1828; Hym. Eur., 622. 1874.
Poria mucida (Pers.) Fr. *sensu* Bres., Hym. Hungarici Kmetiani, 84. 1897.
Poria consobrina Bres. *sensu* Bourd. et Galz., Hym. de France, 671. 1927.
Polyporus vaporarius (*Poria vaporaria*) Fr., in English literature.

Type, cotype, and important specimens:

Irpex paradoxus (Schrad.) Fr. on Fagus. "Typicus." Herb. of Bresadola, Stockholm.
Irpex obliquus Fr. from Boudier. Herb. of Bresadola, Stockholm.
Poria mucida Pers., "orig. exempl." Persoon. Herb. of Bresadola, Stockholm.
Irpex deformis Fr., det. Bresadola, Göteborg, 1897. Herb. Mycolog. Lars Romell 13023, Stockholm.

[2] It is to be noted in the literature of this and other species that there is considerable confusion in the nomenclature, some of the specimens being assigned to Polyporus, some to Poria; and where this confusion exists it frequently happens that the specific name is not in grammatical agreement with the name of the genus. In the present paper the incorrect forms have been retained only where there is direct reference to the older synonymy, the correct forms being used elsewhere.

Irpex obliquus (Schrad.) Fr., on Quercus. "Typicus." Prenčow, 1892. Leg. Andr. Kmet. Herb. of Bresadola, Stockholm.

Polyporus versiporus, Särö, 1914. Herb. Mycolog. Lars Romell 13035, Stockholm.

Poria ochracea Murr. on Quercus, Crabbottom, Virginia, 1904. W. A. Murrill 183. Herb. New York Botanical Garden, New York.

Fructification annual or perennial, i.e. fungus often living through the winter, broadly effused or occurring in interrupted patches and often extending 1 meter or more on log or on dead standing wood, coriaceous, mostly 1–2.5 mm. thick (in the form *Poria versipora* f. *radula* up to about 4 mm. thick); margin "pinkish buff," fimbriate to cottony, 1–4 mm. but mostly less than 2 mm. wide, and often becoming fertile; subiculum less than 0.5 mm. wide, "pinkish buff"; tubes 1–2 mm. long, seldom stratified, and if so, rarely in more than two layers; mouths 1–3 to a mm., "cinnamon-buff"; dissepiments thin, often becoming somewhat dentate; basidia 2–4-spored, 11–17 × 3–5 μ; spores ellipsoidal, 4.5–6 (5 × 3.5) 3–4 μ, 1-guttulate; hyphae 2–3 μ, often encrusted, clamp connections minute, no cystidia.

The names suggested by Romell (16) for two growth forms of *Poria versipora* are listed for convenience:

Forma *deformis:* the name used for specimens which exhibit the type of growth caused by the plant's occurring on vertical surfaces.

Forma *radula:* The name used for specimens which have crenulate or serrulate pore walls (*Poria mucida* var. *radula* Bourd. et Galz., *Polyporus radula* Pers. *sensu* Romell, *Irpex paradoxus* (Schrad.) Fr. *sensu* Bresadola, *Irpex obliquus* (Schrad.) Fr. *sensu* Bresadola, *Irpex deformis* Fr. *sensu* Bresadola).

Remarks. — This plant is so variable that it seems unreasonable to propose a new combination of names for a species that has been referred to so much in the literature under the genus Poria and for a plant already so overloaded with synonyms and interpretations.

Donk (3), however, retains the name Polyporus. With reference to the old names, Romell's remarks concerning the different interpretations of this species illustrate the need for adopting some understandable designation. He states:

"Fries' unpublished picture of *Pol. mucidus* is taken from von Post and seems to show *Pol. corticola* . . . . Persoon's *Pol.*

mucidus (at least the specimens marked 'Obs. Myc.') is identical with Bresadolas' *Poria mollusca*. Bresadola's *Poria mucida* (at least some of the specimens in his herbarium) seems to be *Pol. versiporus* Pers. The specimen on Betula (no. 55 from Eichler) is the resupinate form of Bresadola's *Pol. ravidus* [= *Coriolus washingtonensis*].

"Persoon's herbarium contains three specimens with this name [*Polyporus radula*] . . . one . . . may possibly be a hydnoid form of *Polyporus abietinus*. Another . . . recalls *Pol. corticola* and *Pol. versiporus*. If it is either of these, it can only be the latter, as the hyphae have fibulae [clamps]. The third specimen is also labelled '*Poria radula*' (without hesitation) and has fibulate hyphae. It therefore seems probable to me, that *Pol. radula* of Persoon belongs to *Pol. versiporus*. . . . Perhaps we come nearest to the truth, if we use the name *Poria radula* for the form of *Poria versipora*, which has crenulate or serrulate pore-walls. Bresadola seems to have placed different species under the name *Poria radula* in his herbarium. . . . Probably none of these, excepting No. 3, is referable to *Poria radula* in the sense of Persoon and Fries.

"*Polyporus versiporus*. This is a good species which has nothing to do with *Pol. vulgaris* and *Pol. vaporarius* though referred by Fries to both. There are several specimens of it in Persoon's herbarium. . . . It is . . . frequent in England . . . and passes there under the name *Poria vaporaria* [probably owing to Fries's references].

"Bresadola seems to use the names *Poria mucida* and *Irpex deformis* for this plant. There is no authentic specimen nor any picture of *Irpex deformis*. But in Fries' herbarium occurs a specimen of *Poria versipora* from Chaillet. Fries has not noted any opinion of it, unless it be this specimen he means in El. p. 120 and Hym. Eur. pp. 578, 579. If he had recognized his *Irpex deformis* in it, he would have rather mentioned it under that species. Nevertheless, I suspect that *Irpex deformis* is not specifically distinct from *Poria versipora*, and I would propose to use the name '*forma deformis* Fr.' for specimens growing on vertical surfaces as these have a somewhat different habit."

Donk (3) agrees that the specific name *versiporus* is the correct one and lists the forms into which Persoon divided his species,

namely: (*a*) *immutatus*, (*b*) *sistotremoides*, (*c*) *angulatus*, (*d*) *deflexus*, (*e*) *langugosus*, (*f*) *farinosus*.

In the present treatise, however, a broad interpretation is preferred, and the varieties named are restricted to those suggested by Romell.

Allied species. — Because of the great variability of the growth forms of this species, the plant may be mistaken at times for certain species of the genus Irpex or Polyporus and also of Radulum. Poorly developed or short-tubed forms of *Irpex tulipifera* may seem difficult to separate from *Poria versipora*. The spores of the former are cylindric, 5–6 × 1–2 μ (Overholts), whereas those of *P. versipora* are ellipsoidal, 4.5–6 (5 × 3.5) 3–4 μ.

Occasionally *Radulum casearum* (Morgan) Lloyd and *R. pallidum* E. & E. have been confused with species of Poria and have been sent to me by correspondents for determination. The hymenium of these corky resupinate epixylous plants is warty rather than poroid.

Poria proxima Bres. resembles *P. versipora* in color, tube size, and character of pore mouths. The hyphae of both plants may be encrusted. The distinct cystidia in the hymenial layer of *P. proxima* may be used to separate the two plants. Care should be taken not to confuse the encrusted hyphal ends to be seen in sections made of *P. versipora* for typical cystidia.

Habitat. — *Acacia sp., Acer circinatum, A. rubrum, Alnus incana, A. rhombifolia, A. rubra, A. rugosa, A. tenuifolia, Betula lutea, Carpinus caroliniana, Castanea dentata, Cedrus arbor, Cornus florida, Eucalyptus globulus, Fagus grandifolia, Ilex opaca, Juglans cinerea, Liquidambar styraciflua, Lithocarpus densiflora, Magnolia Fraseri, M. virginiana, Melaleuca incana, Nyssa sylvatica, Phoenix dactylifera, Pinus radiata, Populus trichocarpa, Prosopis juliflora, Prunus serotina, Quercus alba, Q. densifolia, Q. garryana, Q. laurifolia, Q. marilandica, Q. nigra, Q. rubra, Q. stellata, Q. virginiana, Ulmus americana, Umbellularia californica, Vitis sp.*

Distribution. — British Columbia, Ontario, Alaska, Arizona, Arkansas, California, Connecticut, Delaware, District of Columbia, Florida, Idaho, Illinois, Indiana, Iowa, Kansas, Kentucky, Louisiana, Maine, Maryland, Massachusetts, Michigan, Minnesota, Mississippi, Missouri, Montana, New Jersey, New York, North Carolina, Ohio, Oregon, Pennsylvania, Rhode Island, South

Carolina, Tennessee, Texas, Virginia, Washington, West Virginia, Wisconsin.

Polyporus unitus Pers., Myc. Eur., 2 : 93. 1825

Polyporus xantholoma Schw., Trans. Am. Phil. Soc., II, 4 : 158. 1832.
Polyporus pulchella Schw., *l.c.* (var.) Pers., Myc. Eur., 2 : 100. 1825.
Poria pulchella (Schw.) Cooke, Overholts in Mycologia, 15 : 219. 1923.
Polyporus medulla-panis, Bres. in Atti. Accad. Sc. Lett., Agiati III, 3 : 84. 1897.
Polyporus medulla-panis, Bourd. et Galz., Hym. de Fr., 684. 1928.
Polyporus medulla-panis, Shope in Ann. Mo. Bot. Gard., 18 : 398. 1931.
Poria medulla-panis (Pers.) — non *Polyporus medulla-panis* (Jacq.) *sensu* Fr. 1821; nec. *Poria medulla-panis* (Fr.) Sacc. 1888.
Polyporus alabamae Berk. & Cooke; Berk. & Curt. (in part), Grevillea, 6 : 130. 1878.
Polyporus omoema Berk. (probably misprint for "*amoena*" — in part), Cooke, Grevillea, 15 : 26. 1886.
Poria tenuis (Schw.) Cooke (in part), Grevillea, 14 : 114. 1886.

Types and important specimens:

Polyporus unitus Pers. Herb. of Persoon, Leiden.
Poria chrysella Egeland on birch in Seljord, 1912. Herb. of Bresadola, Stockholm.
Polyporus pulchellus Schw., Bethlehem, Pa. Herb. of Schweinitz, Herb. of the Philadelphia Academy of Science, Philadelphia.
Poria (or *Pol.* ?) *alabamae* B. & C., on Myrica, Gainesville, Florida. Type. H. W. Ravenel. Fungi Americani Exsiccati, Herb. New York Botanical Garden, New York.
Physisporus varicolor Karst. on *Alnus incana*, Mustiala. Ex Karsten. Herb. of Bresadola, Stockholm.
Physisporus vitellinulus on Alnus, Mustiala. P. A. Karsten. Herb. of Bresadola, Stockholm.
Poria albo-incarnata Pat. & Gail. Herb. Champignons du Haut-Orenoque. Par. A. Gaillard. Herb. of Bresadola, Stockholm.
Polyporus xantholoma Schw., Salem. Herb. of Schweinitz, Herb. Philadelphia Academy of Science, Philadelphia.
Polyporus alabamae B. & C. Ravenel on *Myrica cerifera*, Gainesville, Florida. Herb. New York Botanical Garden, New York.
Polyporus tenuis (Schw.) Cooke on *Castanea dentata*, Bethlehem, Pa. Herb. of Schweinitz, Herb. Philadelphia Academy of Science, Philadelphia.

Fructification annual or perennial, effused for up to 20 cm. or more, but usually less, mostly inseparable, up to 8 mm. but usually about 3 mm. thick; margin at first sterile, thick, rounded, undulating, tomentose, less than 0.5–1.5 mm. wide, "cartridge-buff" to "Saccardo's umber," becoming fertile with age, and in old specimens becoming "snuff-brown"; subiculum white to "cartridge-buff"; distinct, up to 1 mm. but mostly less than 0.3 mm. thick; tubes 0.5–3 mm. long each season, sometimes stratose,

but indistinctly stratified; mouths pure white, "buff-yellow," or "ivory-yellow" when fresh, circular, thick-walled, entire, 3–7 to a mm., mostly over 5 to a mm.; basidia 4-spored, 3–9 × 15–24 μ, spores hyaline, smooth, 1-guttulate, subtruncate, ellipsoid to oblong-ellipsoid, 4–7 (4 × 5) 3 – 6 μ; no cystidia, but sometimes paraphysis-like structures 20–25 × 8–11 μ present; hyphae thin, narrow, frequently encrusted, much branched, 1–2.5 μ in diameter; without cross walls and clamp connections.

Forms. — This common plant presents a series of growth forms, a fact which, in part at least, accounts for the large number of names attached to the fungus. In color alone the forms may vary from the golden yellow of "*Poria chrysella*" through the egg-yellow of "*Poria pulchella*" to the whitish or snow-white of *Polyporus unitus*. The leathery or corky texture is generally similar in all, but marginal features may differ in the various forms. Characteristic specimens of the "*Pol. tenuis–Pol. alabamae*" forms show broad margins which ramify over the branches, twigs, and leaves of the substratum. Under favorable moisture conditions they may become somewhat rhizomorphic. Usually these forms are softer, more pliable than typical specimens of *Pol. unitus*, and do not tend to crack upon drying.

Certain of the forms in the series are so commonly found in the field that for convenience they are designated by name. It is possible to culture some of these under varying conditions of light and to cause them to change color and growth habits. White forms, for example, can be converted into yellow, and yellow plants into those which are entirely white.

Polyporus unitus f. **pulchella,** comb. nov.

Fructificatio siccitate saepe rimosa; porae nondum siccae $\frac{1}{5}$ $\frac{1}{6}$ mm. diam., plus minusve pallide ochraceo-luteae; margo crassus, rotundatus, haud latus, sterilis vel subiculosus vel rhizomorphus; sporae 4–7 × 3–6 μ, saepissime 4 × 5 μ; hyphae ramosissimae.

Fructification often checking upon drying; pore mouths 5 6 to a mm., "buff-yellow," "ivory-yellow," and other yellow shades when fresh;[3] margins thick, rounded, and not broad, sterile, or appear-

[3] *Pol. unitus tenuis* is often "ivory-yellow" (a very pale yellow), but this frequently shades into "pinkish buff." The bright yellows rather than the buffs are more characteristic of *P. unitus pulchellus*.

ing in sheets of mycelium (subiculose), or rhizomorphic; spores 4–7 (4 × 5) 3–6 μ; hyphae much branched.

This form is distributed widely throughout the continent and occurs so commonly in the West that collections from there were at one time kept separate from those made in the East. The records of its occurrence by region show that it cannot be considered more prevalent in the West than elsewhere.

The name applies to all those forms which are bright yellow, orange-yellow, and egg-yellow. Plants which have been named *Poria chrysella* are also grouped here.

Physiologically, many of the yellow plants are identical with those which are white. Cultures made from strictly white forms exhibit yellows, and yellow plants become white when light conditions are altered.

Cultures. — Isolated from *Populus balsamifera* on Burnt Island, Great Slave Lake, Northwest Territories, and from *Populus tremuloides* at Selkirk, Yukon Territory. Both fungi grow more rapidly in the dark than in the light, and the cultures of both vary from white to yellow. The fungus from the Northwest Territories belongs to the "rapid-growth" group of resupinate polypores and falls into both the "large-range" and "high-temperature" categories. The "ivory-yellow" or "colonial buff" mycelium exhibits a concentric-ring to radiating type of growth in cultures kept in the light for fourteen days. Mycelium cultured in the dark is white to "Marguerite yellow." Pore formation appeared in some of the cultures within this period, whether they had been kept in the light or the dark. No pores were formed in cultures of the same age of the plant obtained from the Yukon Territory.

Like and different features of forms of the resupinate polypores are often more apparent if the fungi are grown under adverse conditions or at least upon substrata ordinarily foreign to them. Both the yellow and the white forms of *Polyporus unitus* (the two plants occur on frondose woods in nature) produce less mycelial covering on white-pine than on hardwood test pieces in one-year-old cultures. Isolates of neither the *pulchella* form nor the white form of *Pol. unitus*, referred to as *medulla-panis*, mask the wood unless a hardwood block is placed in the same flask. Even in such cultures the coniferous block is not always covered.

Both forms are white and exhibit a more or less arachnoid mycelial growth on the coniferous wood in contrast to the thick chamois-like covering in red-gum block cultures. Pore formation appears on both red-gum and white-pine blocks in *medulla-panis* cultures, but no pores occur on either the hardwood or the coniferous blocks in one-year-old cultures of the *pulchella* form.

The one-year-old cultures of the *medulla-panis* form on white pine are noteworthy since the pores make up a more conspicuous part of the culture than the arachnoid mycelium. The cultures on coniferous wood exhibit a fructification which immediately suggests that of *Poria xantha*, or *P. xantha* f. *crassa*, found so commonly on conifer-wood structures in weave and textile sheds and in other buildings habitually wet. Macroscopically the fructifications appear to be duplicates of those of *P. xantha* and *P. xantha* f. *crassa* which often occur on large fallen western conifers and other woods. *P. xantha* and *P. xantha* f. *crassa* are common on beams, girders, and other timbers in retail lumber and mill yards, especially in the Northwest and in certain other regions. Both whitish and very pale yellow fructifications of these fungi occur in nature and in culture. *P. xantha*, furthermore, appears on both hardwoods and conifers in arctic regions. I have found it common on both spruce and willow in the lower Mackenzie River districts.

Spore measurements are reliable features to separate the yellow forms of *Polyporus unitus* and *Poria xantha* should environmental conditions favor the growth of the frondose plants on coniferous wood in nature and so lead to difficulty in distinguishing them from the usually conifer-inhabiting plant *P. xantha*.

The spores of both *Poria xantha* and *P. xantha* f. *crassa* are 1–1.5 × 4–6 μ; those of *Polyporus unitus*, 3–6 (4 × 5) 4–7 μ.

Polyporus unitus f. **tenuis,** comb. nov.

Fructificatio siccitate plerumque non rimosa; porae $\frac{1}{4}$–$\frac{1}{5}$ mm. diam., pallidissime ochraceo-luteae, rubidiuscule ochraceae vel pallide cinnamomeae; margo latus, sterilis, tomentosus, saepe subiculosus, interdum rhizomorphus; sporae 3–4.5 × 3–5 μ, plerumque 3 × 4.5 μ; hyphae ramosissimae.

Fructification uncommonly checking upon drying; pore mouths 4–5

to a mm., "ivory-yellow," "pinkish buff" to "cinnamon-buff"; margins broad, sterile, tomentose, often forming sheets of mycelium (subiculose), and sometimes rhizomorphic; spores 3–4.5 (3 ×4.5) 3–5 μ; hyphae much branched.

Characteristic specimens of this plant are more "pliable" than those of *Polyporus unitus* or of the *pulchella* form. Although widely distributed in regions east of the Mississippi River and particularly common in the northern region of the Great Lakes, New England, the southern Appalachians, and the South Central part of the eastern United States, the plant is more restricted in its occurrence than is *Pol. unitus* or *Pol. unitus* f. *pulchella*. In general, it is not a western plant.

Cultures. - Isolated from chestnut, Great Falls, Virginia. Cultures of this fungus are predominately white for at least six months. Small strands of mycelium or rhizomorphs are distinctive and appear on the inoculum in cultures of this form, but have not been noticed in ones of *Polyporus unitus*. *Pol. unitus* fruits in the diffuse light of the laboratory, but cultures of the variety *tenuis* grown under similar conditions have not shown any indication of hymenophore formation.

Allied species. — Reference has been made in the literature to specimens in the series which resemble *Poria subacida* Pk. The tubes of *P. subacida* are generally longer and the dissepiments thinner than those of *Polyporus unitus*. The usually narrow and much-branched hyphae of the latter are distinctive.

Macroscopically, forms of *Polyporus unitus* may suggest *Poria ferox* since the colors "cartridge-buff," "pinkish buff," and "cinnamon-buff" are sometimes common to both. The hyphae are seldom branched in *P. ferox*. Decay in the frondose woods attacked by *Pol. unitus* is not cubical, and the mycelium does not form sheets or mats in the rotten wood. *P. ferox* is known only on conifers; it does not cause a white rot. Sheets of mycelium form in the decayed wood (Plate IV).

Specimens of *Poria albo-incarnata* Pat. suggest *Polyporus unitus* macroscopically, and the spores of the two plants may be similar in size. Unlike *Pol. unitus*, *P. albo-incarnata* turns scarlet red when KOH is applied.

Habitat (of the species and its forms). — *Acer rubrum*, *A. saccharinum*, *Alnus sp.*, *Arbutus xalapensis*, *A. halopensis*, *Artemisia californica*,

Betula occidentalis, B. papyrifera, Carya ovata, Castanea dentata, Ceanothus thyrsiflorus, Cornus florida, Fagus grandifolia, Fraxinus nigra, Gleditsia triacanthos, Gymnocladus dioicus, Hamamelis virginiana, Juglans nigra, Liriodendron tulipifera, Myrica cerifera, Parthenium argentatum, Populus balsamifera, P. tremuloides, P. trichocarpa, Prunus persica, P. serotina, Quercus alba, Q. borealis maxima, Q. lobata, Q. prinus, Q. utahensis, Q. velutina, Q. virginiana, Rhus toxicodendron, Robinia pseudoacacia, Salix nigra, Tilia glabra, Ulmus americana.

Distribution (of the species and its forms). — Manitoba, Northwest Territories, Ontario, Quebec, Yukon Territory, Alabama, Arizona, Arkansas, California, Colorado, Connecticut, Delaware, Florida, Georgia, Idaho, Illinois, Indiana, Iowa, Kansas, Kentucky, Louisiana, Maine, Maryland, Massachusetts, Michigan, Minnesota, Mississippi, Missouri, Montana, Nebraska, New Hampshire, New Jersey, New Mexico, New York, North Carolina, Ohio, Oregon, Pennsylvania, Rhode Island, South Carolina, South Dakota, Tennessee, Texas, Utah, Vermont, Virginia, Washington, West Virginia, Wisconsin.

Trametes Trogii Berk., Mitth. Schw. Naturf. Ges., 2 : 52. 1850

Trametes Trogi Berk., Konrad and Maublanc, Icones selectae fungorum, 1 : 444. 1924–30.

Trametes hispida subsp. *T. Trogii* (Berk.) Bourd. et Galz., Bull. Soc. Myc. Fr., 41 : 163. 1925.

Fructification sessile or semiresupinate, usually small but sometimes up to 15 cm. long, 0.5–10.5 × 3–15 × 0.5–2 cm.; surface densely ochraceous to tawny, pubescent, weathering gray and becoming fibrous; context whitish, "cartridge-buff," or "cream-buff"; tubes mostly 2–10 mm. long; mouths 1–2 to a mm.; spores cylindrical, hyaline, 7–11.5 × 2.5–3.5; hyphae hyaline, aseptate, 2–6 μ in diameter.

Allied species. — This species is closely related to *Trametes hispida.* Both plants occur usually on willow, aspen, or poplar. It is possible to separate the two plants by the color of the context, which is whitish or at least not dark brown in *T. Trogii,* but is dark brown in *T. hispida.* The pileus is not ordinarily so conspicuously hirsute in *T. Trogii* as in *T. hispida.* Both plants may

be semiresupinate, but *T. Trogii* occurs in that state more frequently.

Habitat. — *Aesculus californica, Populus tremuloides, Quercus macrocarpa,* and *Salix sp.*; also occurs on *Fomes fomentarius.*

Distribution. — Ontario, Alaska, California, Connecticut, Nebraska, New Hampshire, Pennsylvania, Vermont.

Trametes malicola Berk. & Curt., Journ. Acad. Phila., 209. 1856

Important specimen:

Trametes malicola Berk. on *Pyrus malus,* Kentucky. C. G. Lloyd 07665. Herb. of Bresadola, Stockholm.

Fructification effused, reflexed, or entirely resupinate; pileus 1–10.5 × 0–1 × 0.4–2 cm., glabrous or nearly so, "cartridge-buff" to "warm buff"; context "pinkish buff," 1–5 mm. thick; tubes 1.5–5 mm. long; mouths concolorous with the context, round to angular, mostly 2 to a mm.; basidia 12–15 × 4 μ; spores cylindric, 8–12 × 3.5–4 μ; hyphae occasionally branched, 2.5–4.5 μ.

Allied species. — *Trametes malicola* is sometimes confused with *T. sepium.* The context of *T. malicola* is light brown or wood-colored, while that of *T. sepium* is whitish or not truly brown.

Cultures. — Isolated from *Populus grandidentata,* Ann Arbor, Mich. This fungus, which is found only on hardwoods in nature, grows readily on hardwood blocks in culture and first covers them with a white mycelial growth which within a year becomes "pinkish buff" to "cinnamon-buff." No pores are formed. The mycelium does not grow readily on conifers and after one year in culture on white-pine blocks only covers less than one fourth of the block faces. It is noteworthy, however, that the pine is stained a conspicuous bright red for a distance of at least one half inch beyond any outward visible mycelium — a condition which suggests the early stages of red rot caused in pine by *Fomes pini.* The "avellaneous" or "pinkish cinnamon" color of the pine blocks turns "Nopal red" in advance of the mycelium in such cultures.

Cultures of *Trametes malicola* make their best growth in the dark. This plant belongs to the "slow-growth" group of Porias and in the "large-range" temperature group. It has been placed in the "average temperature" class for best growth.

Habitat. — *Acer negundo, A. rubrum, A. saccharinum, A. saccharum,*

A. spicatum, Ailanthus sp., Benzoin aestivale, Carya alba, C. glabra, C. laciniosa, C. ovata, Populus tremuloides, Malus pumila, Rhus vernix, Tilia glabra.

Distribution. — British Columbia, Ontario, Alabama, Connecticut, District of Columbia, Indiana, Iowa, Kentucky, Louisiana, Maine, Michigan, Minnesota, Missouri, Nebraska, New Hampshire, New Jersey, New York, Ohio, Oklahoma, Pennsylvania, Tennessee, Vermont, West Virginia, Wisconsin, Wyoming.

Occurrence. — *Trametes malicola* is most commonly found on *Malus pumila* and *Acer rubrum.*

Poria canescens Karst., Rev. Myc., 10. 1887

(Plate V, Figs. 1–2)

Important specimen:

Physisporus canescens Karst. on *Alnus incana*, Mustiala, ex Karst., Herb. of Bresadola, Stockholm.

Fructification annual, effused in irregular patches for as much as, but usually less than, 25 cm., about 3 mm. thick; margin fimbriate, whitish up to 5 mm. wide, but mostly much less; subiculum 0.5 mm. thick, often disappearing in old plants; tubes 1–3 mm. long; mouths 4–5, mostly 4 to a mm., when fresh white to "light drab" to "drab gray," turning "army-brown" to "Natal brown" upon bruising; basidia 7–14 × 3–7 μ, 4-spored; spores hyaline, allantoid-reniform, 4–6 × 2–3 μ; hyphae hyaline, mostly nonseptate, 2–3 μ in diameter.

Allied species. — Some collections of this species labeled *Poria cinerea* Schw. are deposited in various herbaria. Since no specimens of *P. cinerea* exist either in the Schweinitz herbarium or in the Michener collection in Washington, it is difficult to interpret the Schweinitz plant. The description may fit several plants which are ashy in color. *P. cinerea* was reported on Liriodendron, and this is a wood on which *P. canescens* frequently occurs.

Bresadola was of the opinion that *Poria canescens* was closely related to *Polyporus subspadicea* Fr. A plant labeled *Pol. subspadicea* in the Bresadola herbarium in Stockholm suggests *Pol. adustus* macroscopically, but the spores are given as 7–9 × 3.5–4 μ. The spores of *Pol. adustus* are smaller both in length and width. The European interpretation of *Pol. subspadicea*

is so varied that it is doubtful if this plant can be accurately compared with *P. canescens*.

Poria canescens has also been labeled *P. salmonicolor* Berk. & Curt. Many distinct species which turn red or brown-red upon bruising or drying have been placed under this name. The specimen of *P. salmonicolor* Berk. & Curt. marked "type" in the herbarium of Berkley, 1879, at Kew is actually *P. spissa*.

Immature and resupinate specimens of *Trametes Trogii* and *T. mollis* (Somm.) Fr. suggest *Poria canescens*, but the size of the pore mouths can be used as a basis for distinguishing these plants. The pore mouths of *T. Trogii* and *T. mollis* (Somm.) Fr. are mostly 3 or less than 3 to a mm., whereas those of *P. canescens* are 4–5 to a mm.

Habitat. — *Acer rubrum, Carya sp., Fagus grandifolia, Liquidambar styraciflua, Liriodendron tulipifera, Populus tremuloides, Ulmus americana.*

Distribution. — Ontario, Yukon Territory, Connecticut, District of Columbia, Georgia, Indiana, Louisiana, Maryland, Michigan, North Carolina, Ohio, Vermont, Virginia, Washington, West Virginia.

Poria fimbriatella (Peck) Sacc., Syll. Fung., 6 : 303. 1888

Polyporus (*Physisporus*) *fimbriatellus* Peck, N. Y. State Mus. Rep., 38 : 91. 1885.

(Plate VI)

Type:

Polyporus fimbriatellus on maple, Osceola. Type. C. H. Peck. New York State Museum, Albany.

Fructification annual, effused up to 1 meter, but usually only 3–10 cm. long and mostly not over 6 cm. broad, separable; margin white, usually 1–2 mm. wide, tomentose, somewhat fimbriate and often with conspicuous white rhizomorphs; subiculum whitish or "pale pinkish buff," up to 0.3 mm. thick; tubes 1–2 mm. long; mouths "vinaceous buff" to "avellaneous," 4–5, mostly 4, to a mm.; spores smooth, hyaline, ellipsoidal, 2.5–3.5 × 1.5–2 μ; encrusted cystidia present; hyphae somewhat branched, 2–3 μ in diameter; no clamp connections.

Allied species. — Because the names suggest similar types of growth, *Poria fimbriatella* and *P. myceliosa* may be confused. Furthermore, the spores of the two plants are very nearly alike. *P. fim-*

briatella differs from *P. myceliosa* in the presence of encrusted cystidia and in the absence of clamp connections.

Habitat. — *Alnus tenuifolia, Populus balsamifera, P. tremuloides, P. trichocarpa, Quercus Kelloggii.*

Distribution. — Northwest Territories, Yukon Territory, California, New York.

Poria incrassata (Berk. & Curt.) Burt., Ann. Mo. Bot. Gard., 4 : 360. 1917

Merulius incrassatus Berk. & Curt., Hooker's Lon. Journ. Bot., 1 : 234. 1849.
Merulius spissus, Berk., Grevillea, 1 : 70. 1872.
Polyporus pineus Peck, N. Y. State Mus. Rep., 41 : 78. 1888.
Poria pinea Peck in Sacc., Syll. Fung., 9 : 194. 1891.

(Plates VII–XI)

Important specimen:

Poria pinea on pine bark, Selkirk, New York. Type. Ex Herb. New York State, Herb. Mo. Bot. Garden.

Fructification annual, resupinate, on stored lumber and on timbers in buildings, with the mycelium sometimes extending from basement floors up to the third story, drying brittle and often breaking up and falling from the substratum; margin extending out in broad, fanlike structures commonly 120 mm. wide, whitish when young, tinged with yellowish olive, and turning to brown or black in age; whitish rhizomorphs often developing and, when mature, becoming yellowish, turning to brown or black, frequently appearing as heavy rootlike or vinelike growths; fructification when developed in the open often with a thick whitish subiculum which cracks upon drying; tubes not stratified, up to 10 mm. in length, mostly 3–7 mm.; mouths 1–3 to a mm.; spores fuscous or dusky olive when mature, 5.5–7 × 8–12 μ; cystidia not present; hyphae smooth, often branched, varying from 1.1–5.5 μ in diameter.

Allied species. — Fructifications of this plant are not difficult to identify, but frequently one finds only the mycelial growth in the storage sheds, mill yards, and buildings. The mycelium has often been mistaken for that of species of Merulius and of other genera of fungi. Fruiting bodies may develop several feet away from the portions of mycelial growth that cover the wood more conspicuously.

Cultures. — Isolated from "yellow pine," obtained from the United

States Forest Products Laboratory. Young cultures of *Poria incrassata* are white. The mycelium exhibits at first a concentric-ring growth which finally extends out in radiating strands or fans. These turn from white to "chamois" or "amber-yellow" to "Isabella color." The best growth takes place at temperatures ranging from 23° to 30° C., and the species is classified in the "average-temperature" group.[4] The rate of growth in the dark is almost twice as great as that in the light. In two-week-old cultures the mycelium grown in the dark is white, whereas that exposed to the light varies from white to "pinard yellow."

Poria incrassata has been cultured on a great variety of substances. Humphrey (7) grew the fungus on representative species of thirteen genera of conifers and twenty-five genera of broadleaf woods. Approximately one half of the test blocks were so thoroughly decayed at the end of two years that the wood (when dry) could be readily pulverized between the fingers.

Since *Poria incrassata* is considered one of the chief causes of rot in building timbers, much effort has been made to select chemicals which are toxic to the growth of the fungus and which may be used as both desirable and serviceable preventives. The fungus has been cultured on a great variety of substrata containing toxic chemicals and has been found extremely susceptible to many of them (4). Richards (13) concluded that this fungus was the least resistant of a number of wood-rotting organisms to sodium fluoride. Included were such fungi as *Polystictus abietinus*, *Pol. versicolor*, *Lentinus lepideus*, *Stereum fasciatum*, and others.

Ethyl mercury chloride mixtures and ethyl mercury phosphate mixtures, among others, have shown a high degree of fungicidal efficiency. Nonmercurials (many of them exhibiting at least a fair degree or better of toxicity) such as chloroorthophenylphenol, sodium tetrachlorophenolate, and butul phenol have been used. The inhibiting effects of chemicals other than the

[4] Humphrey and Siggers' (9) classification is based upon temperatures ranging between 24° and 32° C. Thirty degrees centigrade has been used as a basis for separation of the groups in the present series of papers. Since *Poria incrassata* grows well at 30°, the fungus might be placed in a higher temperature category. It can be seen, however, that the intermediate (or average) class more nearly expresses the best temperatures for growth, since development is retarded at higher temperatures and since the best growth takes place at those from 23° to 30° C.

benzene derivatives have been tested too. Aniline copper fluoride, copper acid fluoride, aniline copper sulphate, fluorsit, thanalith, and ammonium arsenous trioxide are only a few of those tried. Some of these chemicals, and others, such as the creosotes, are toxic to *Poria incrassata*, but are of chief value for use as fungicides where discoloration of the lumber and other factors do not have to be considered (4).

Habitat. — *Pseudotsuga taxifolia, Pinus palustris, P. ponderosa, Quercus borealis maxima, Sequoia sempervirens, Taxodium distichum.*

Distribution. — Ontario, Alabama, California, District of Columbia, Florida, Georgia, Idaho, Illinois, Kentucky, Louisiana, Michigan, Mississippi, Nebraska, New York, Oklahoma, Oregon, Pennsylvania, South Carolina, Tennessee, Texas, Virginia, Washington.

Occurrence. — The fungus does not occur in the forest,[5] but appears in buildings and stacked lumber. Although in this paper, because of the lack of specific records, comparatively few woods are listed as its habitat, the fungus will, actually, attack any of the commercial species. It is especially common in the South and in the Northwest in buildings where there is a heavy condensation of moisture in walls and between floors and subfloors. Lumber shipments, it is believed, are frequently responsible for its appearance in other localities. The fungus often spreads in the joists and baseboards, and up in door and window frames. Instances have been reported where it has destroyed the timber in the second story of structures and has progressed to the third story.

Although, according to Humphrey (8), the great losses through decay are sustained in those structures where the air is humidified, either by artificial means or through manufacturing processes such as are used in weave and dye sheds in the textile industry and in paper mills, *Poria incrassata* is not the agent of decay in such conditions. It does occur frequently in buildings where moisture is not excessive.

In the South many outbreaks have occurred in lumber yards

[5] Humphrey (7) reports that he found it once on a charred cedar trunk along the roadside at Shelton, Washington, and that earlier investigators had reported it a very few times on stumps or fallen timber in New York and South Carolina. The destruction of a house by *Poria incrassata* is illustrated graphically by Richards (13). "The foundation was fair, but the joists were allowed to rest on a stump which furnished entry for the fungus."

and the fungus is widely distributed through residences and buildings of various types. I have seen it running up concrete posts and progressing through wooden flooring four feet or more from the ground into piles of kiln-dried lumber stacked in dry sheds. Resawing of several thousand feet of this lumber was necessary to salvage that which was still merchantable. The fungus was found also in the open yard. *Poria incrassata* is prevalent on all the chief structural materials used in buildings in the South and West. Hardwood flooring, nail kegs, and oak crating also have been attacked (8). The fungus does occur in the North, but chiefly, however, as the result of shipping lumber in from the South or West. It has been seen in Chicago and Detroit in buildings and lumber.

Decay. — *Poria incrassata* produces a dry rot and causes the wood to check into cubes. In the final stages of decay the rotted timber can be easily crushed to a powder between the fingers.

The fungus itself appears in papery, often fan-shaped, sheets of mycelium, which may form between flooring, frequently spreading upward between the walls. In advanced stages of decay shrinkage cracks appear in the wood. Chief characteristics of use in diagnosing *Poria incrassata* in wood have been summarized by Hubert (6) and listed as: (*a*) brown rot, (*b*) zone lines, (*c*) large bore holes, spiral cracks, (*d*) unconstricted old hyphae.

It has frequently been emphasized that fungi and termites are associated in their destruction of wood and it has often been assumed that *Poria incrassata* is one of the common species of the wood-rotting agents involved. Much damage caused by fungi has been attributed to termites and likewise much loss due to termites has been ascribed to fungi. Observations made in the South, at least, point to the fact that the insect and *P. incrassata* may not live together so closely as is often believed. The environment may be favorable for either one, but if the termite destroys the wood first, conditions may not be so favorable for the fungus. It appears likely that decayed wood, furthermore, is not the most suitable food for the insect. At any rate, the majority of specimens of wood I have collected from buildings decayed by *P. incrassata* do not show termite damage, although the insect could be working in the same structure. Termite tunnels were present, however, on planks exhibiting mycelium of the

fungus in the house shown in Plates VIII–XI. This house is typical of many buildings which are so constructed as to favor fungous development and which have been damaged by *P. incrassata*, for in one foundation wall burlap closes the only ventilator, and, since the house has no basement, brick supporting walls beneath the floors form small rooms that prevent circulation of air. The top of a tile drain beneath the structure is broken and permits evaporation of standing water. Furthermore, a sidewalk on the opposite side of the house lies a few inches below yard level, so that during heavy storms it forms a trough for the rain, which drains beneath the building through a large crack in the stucco wall.

Additional information on the relation of termite activity and rot fungi is greatly needed. It is of interest that Hendee (5) found comparatively few basidiomycetes in association with termites. Two hundred and fifty-eight fungous cultures were made from fifteen colonies of *Kalotermes minor* Hagen, one hundred and twenty from twelve colonies of *Reticulitermes hesperus* Banks, and twelve cultures from twelve colonies of *Zootermopsis angusticollis* Hagen. The colonies were collected in various localities and occurred in at least eleven species of wood. Isolations were made not only from the termites themselves, but also from their fecal pellets, loose detritus or frass within their burrows, and the wood of the walls of the burrows. Since spores were not produced by the basidiomycetes, the fungi in this group were not easily identified, but only six of the twenty nonsporulating cultures of fungi isolated were recognized as being basidiomycetes (5).

Poria nigra Berk. in Hooker's Lon. Journ. Bot., 4 : 304. 1845

Polyporus niger Berk., Hooker's Lon. Journ. Bot., 4 : 304. 1845.
Melanoporia nigra (Berk.) Murr., North American Flora, 9 : 15. 1907.
Poria niger, Grevillea, 53 (1872) : 3.

(Plate XII)

Type, cotype, and important specimen:

Poria niger Berk., Ohio. Type. Herb. Berk., Kew Gardens, London.
Poria nigra B. & Br., Ohio. "Type." Herb. New York Botanical Garden, New York.

Polyporus niger Berk., Cincinnati, Ohio. A. P. & L. V. Morgan ex herb. Calkins. 1890. Herb. New York Botanical Garden, New York.

Fructification effused for 14 cm. or more, woody, inseparable, up to 2 cm. thick; margin sterile, pubescent, "warm sepia," up to 2 mm. wide, becoming black, old tube layers and subiculum forming a horny black layer next to substratum, often with a metallic luster, tubes stratified, uneven, up to 5–7 mm. long each season; mouths "hair-brown," "warm sepia," 4–7, mostly 6, to a mm., regular, edges entire; basidia 8–8.5 × 3–4.5 μ; spores hyaline or pale ferruginous 3 × 3 μ (?), hyphae both light and dark brown, sometimes arranged together so that dark brown hyphae resemble conducting organs, brittle, rarely septate, 2–7 μ in diameter; no clamp connections (but appearing in submerged mycelium in cultures); cystidia none or appearing as dark brown blunt hyphal pegs (rarely sharpened), 11–15 × 4–7 μ.

Allied species. — *Poria nigra* may call to mind an old, weathered and dead, abortive fruiting body of a species of Fomes (*F. Everhartii* for example) or one of the brown resupinates of the Fomitiporia or Fomitiporella group. The very dark chocolate-brown or black fruiting structure of *P. nigra* might, furthermore, suggest that carbon from the burned log or fire scar from which it was growing had discolored the polypore. The dark color is, however, characteristic of the fungus itself. Plate XII shows a specimen which actually has an ungulate form and so resembles a species of Fomes more strikingly than is usual for *P. nigra*.

Fomitiporia cubensis blackens in age and closely resembles *Poria nigra*. The ashy-white character of the pore mouths of this Cuban plant and its tubes stuffed with whitish mycelium are distinctive, however, for the species.

Both *Poria nigra* and *P. megaloporia* Pers. are found on oak. *P. megaloporia* is apt to occur on structural woods as well as in the forest, whereas *P. nigra* is a fungus of the woods. The fructification of *P. megaloporia* is gray-brown, i.e. "drab," "snuff-brown," or "Saccardo's umber" rather than the darker browns of *P. nigra* ("hair-brown," "warm sepia," or blackish). A felty subiculum, as in *Fomes nigrolimitatus*, is often present in *P. megaloporia*, but it does not appear in *P. nigra*. The felty nature of the border of *P. megaloporia* may be used to separate the two plants.

Cultures. — Isolated from *Quercus velutina* from Hardin, Illinois, obtained by Ross Davidson and W. A. Campbell, Division of Forest Pathology, Washington, D.C. Although in culture, isolates of *Poria nigra* vary in color and other characteristics, its mycelium remains white for a much longer period than does that of any of the brown resupinates, with the possible exception of *P. ferrugineo-fusca* (on Douglas fir from Oregon). Save for the fruiting surfaces, which in this isolate of *P. nigra* are mostly "light mouse-gray" or "mouse-gray" in one- and two-year-old cultures, the colors of the mycelium of the two plants are similar. *P. ferrugineo-fusca,* from a conifer, covers red-gum blocks in one-year-old cultures with fully as luxuriant a growth of mycelium as it forms in cultures on white-pine blocks. *P. nigra,* on the other hand, forms only a thin sheet of mycelial growth over parts of white-pine test blocks. This fungus completely masks red-gum blocks with a thick layer of mycelium in one-year-old cultures. The "mouse-gray" fruiting surfaces of "*P. nigra*" should readily distinguish it from *P. ferrugineo-fusca.*

Habitat. — *Quercus alba, Q. borealis maxima, Q. coccinea, Q. velutina.*

Distribution. — Florida, Illinois, Iowa, Michigan, Missouri, North Carolina, Ohio, Pennsylvania, South Carolina, West Virginia, Wisconsin.

University of Michigan

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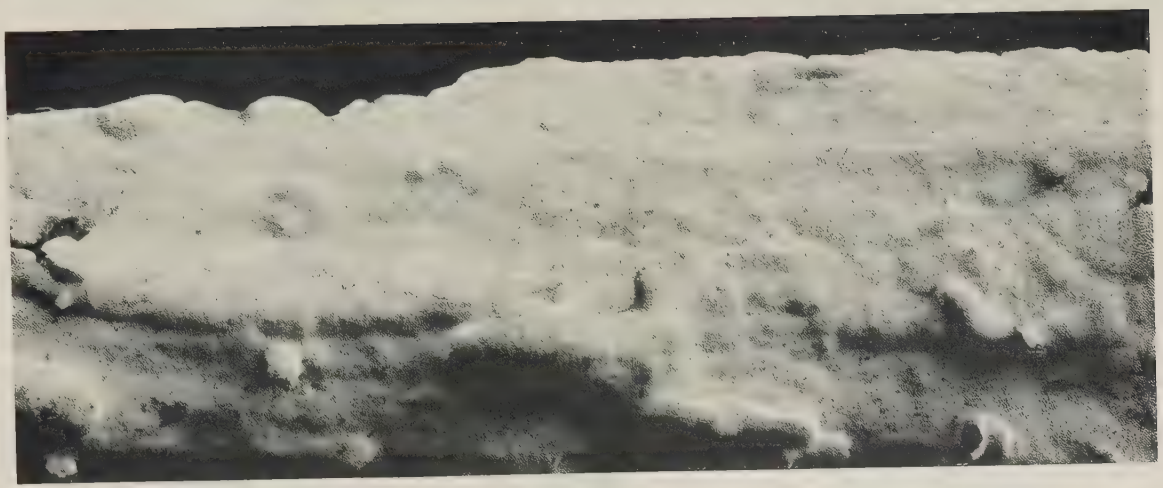
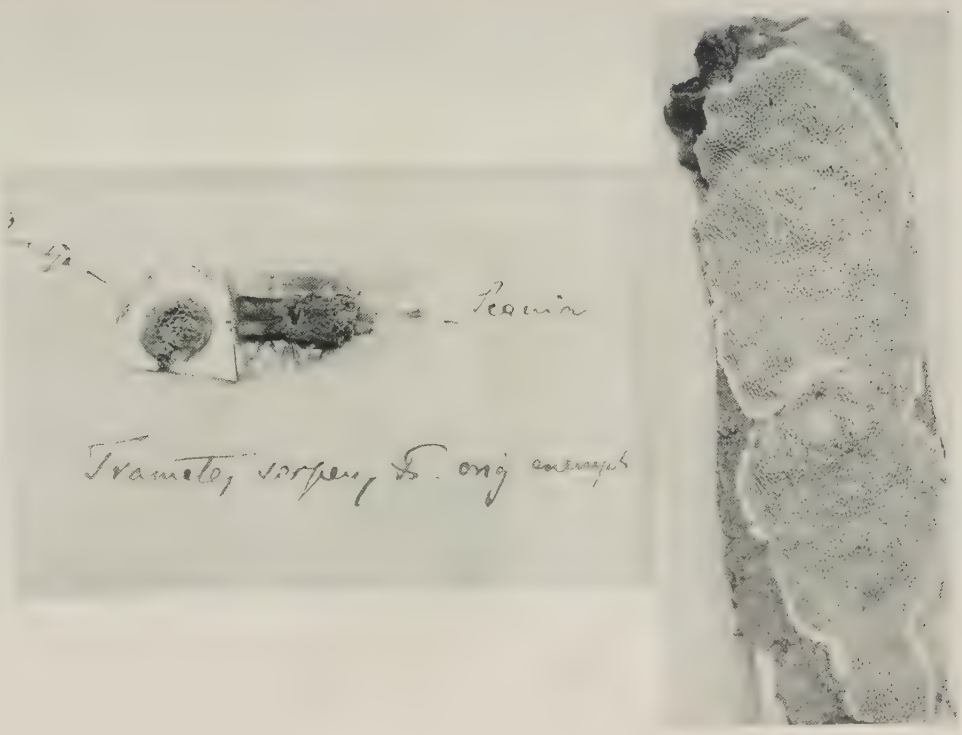
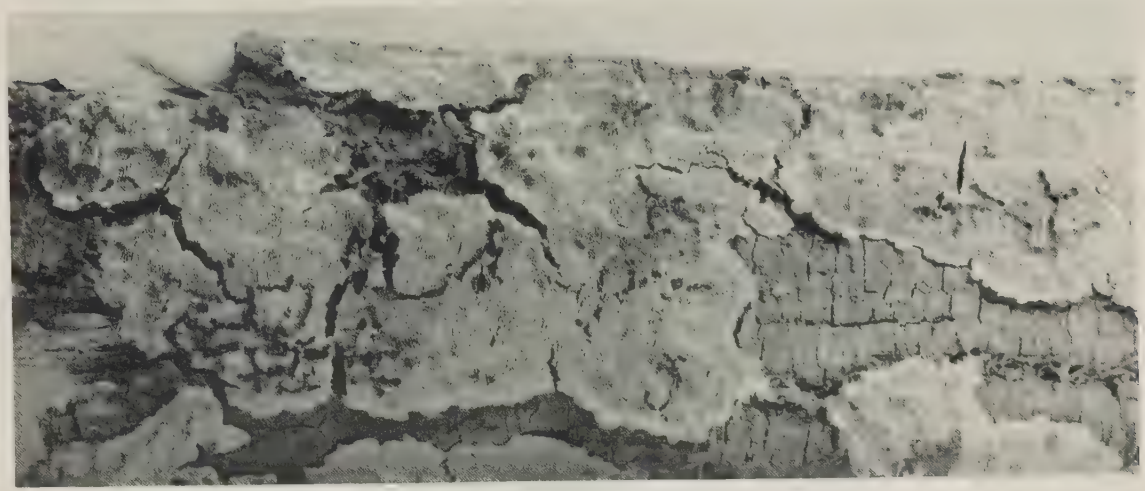


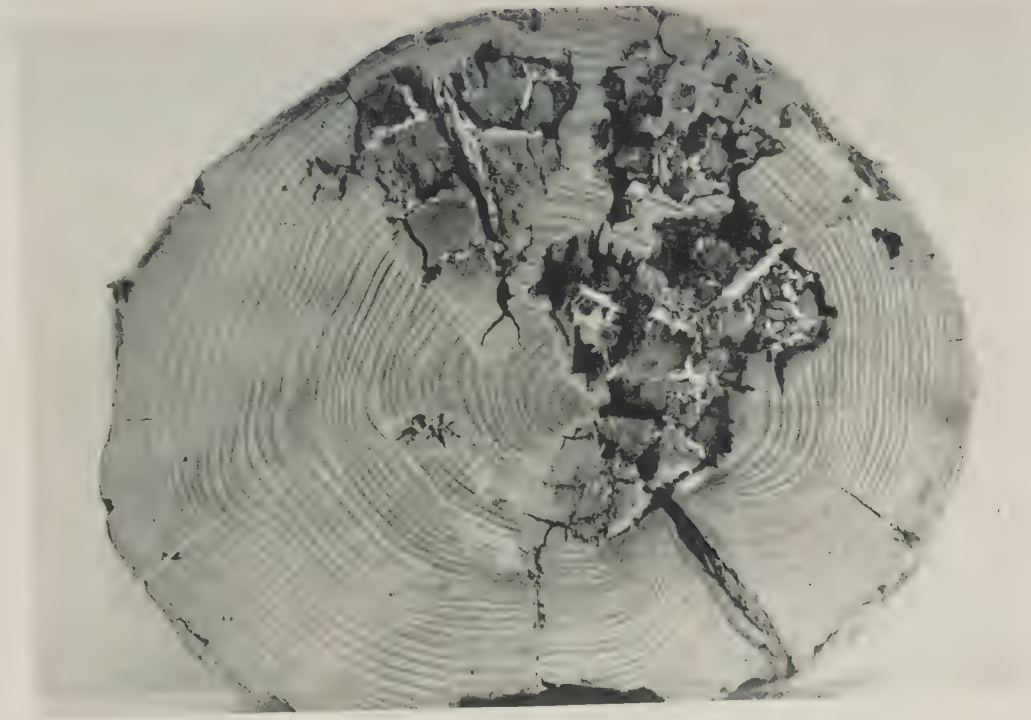
Trametes Morgani Lloyd on *Quercus sp.*, Bland, Virginia



Trametes serpens Fr. Type, Stockholm, Sweden



Trametes serpens Fr. on *Nyssa aquatica*, Natchez, Mississippi



Decay caused by *Poria ferox*, sp. nov., in *Juniperus virginiana*

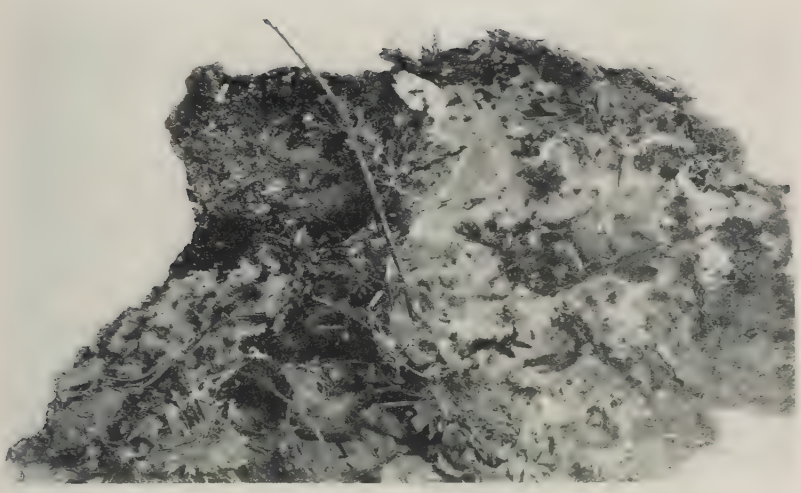


FIG. 1. *Poria (Pol.) canescens* Karst. on beech, Marquette National Forest, Michigan. Coll. and det. D. V. Baxter

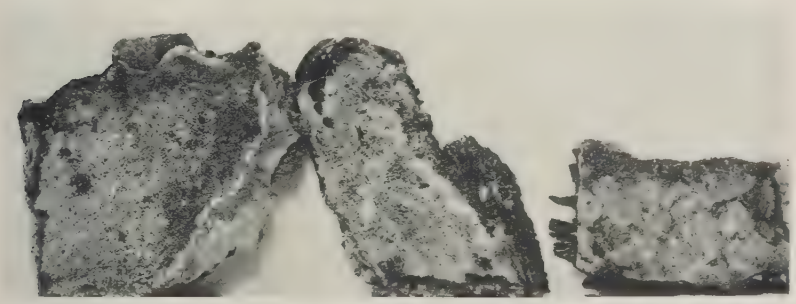
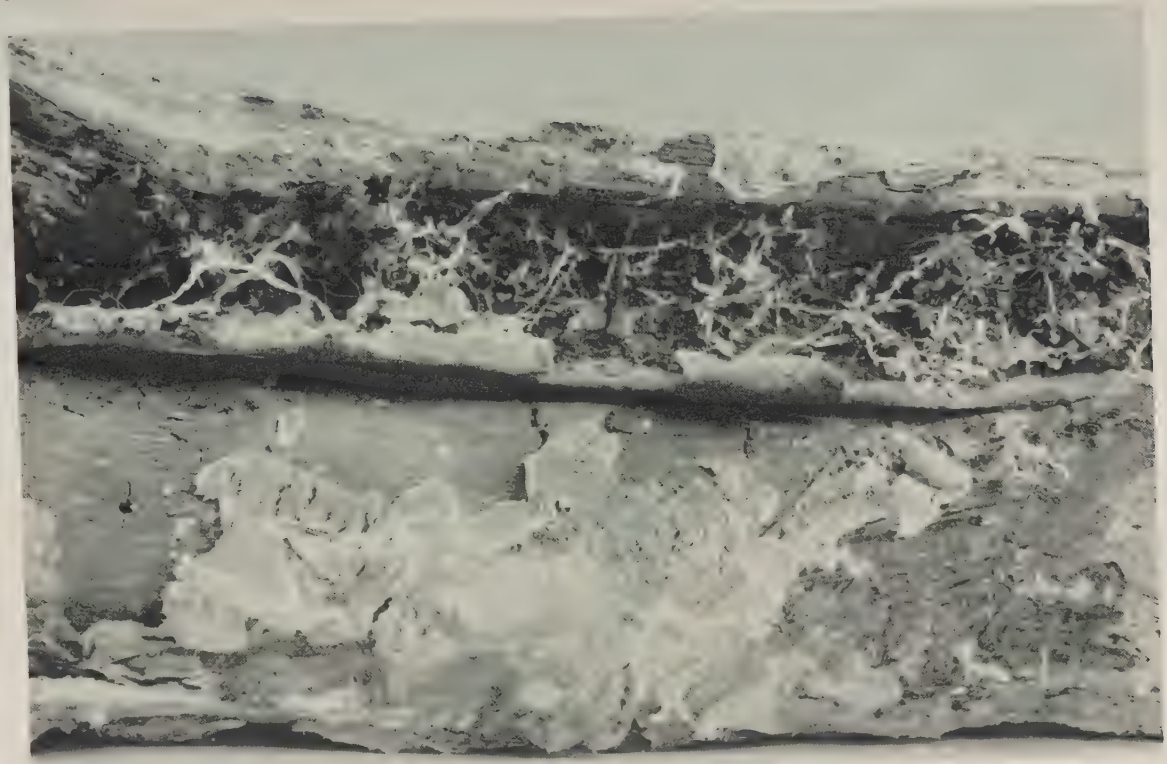
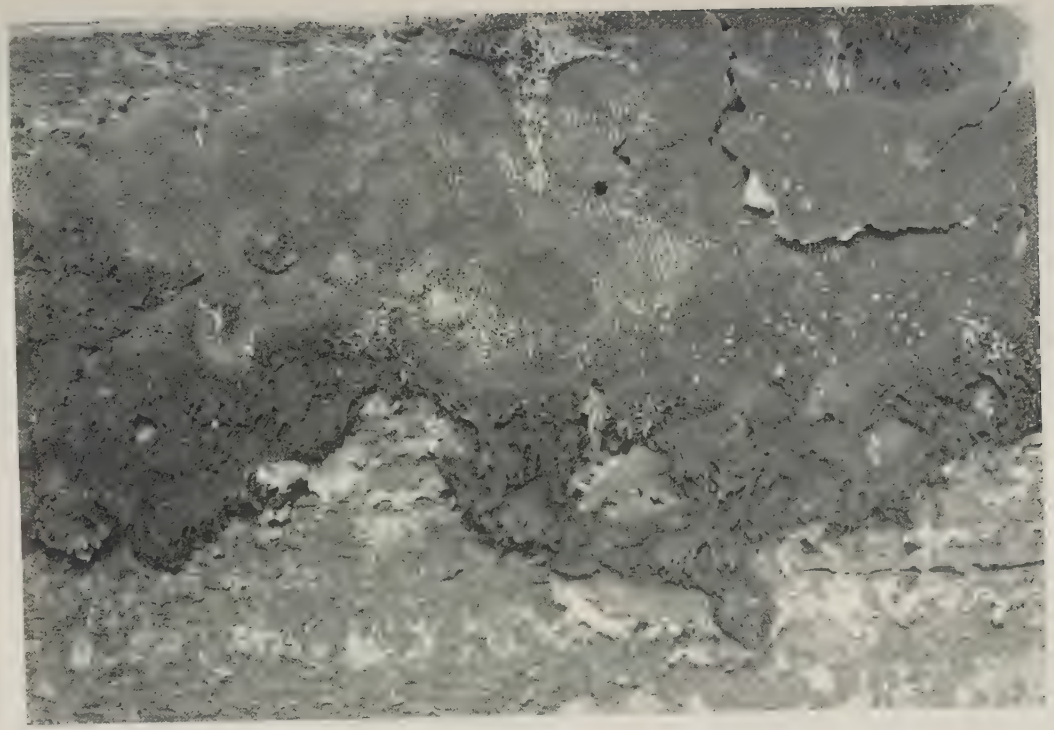


FIG. 2. *Poria canescens* Karst. on *Alnus incana*, Mustiala, Finland, 1886

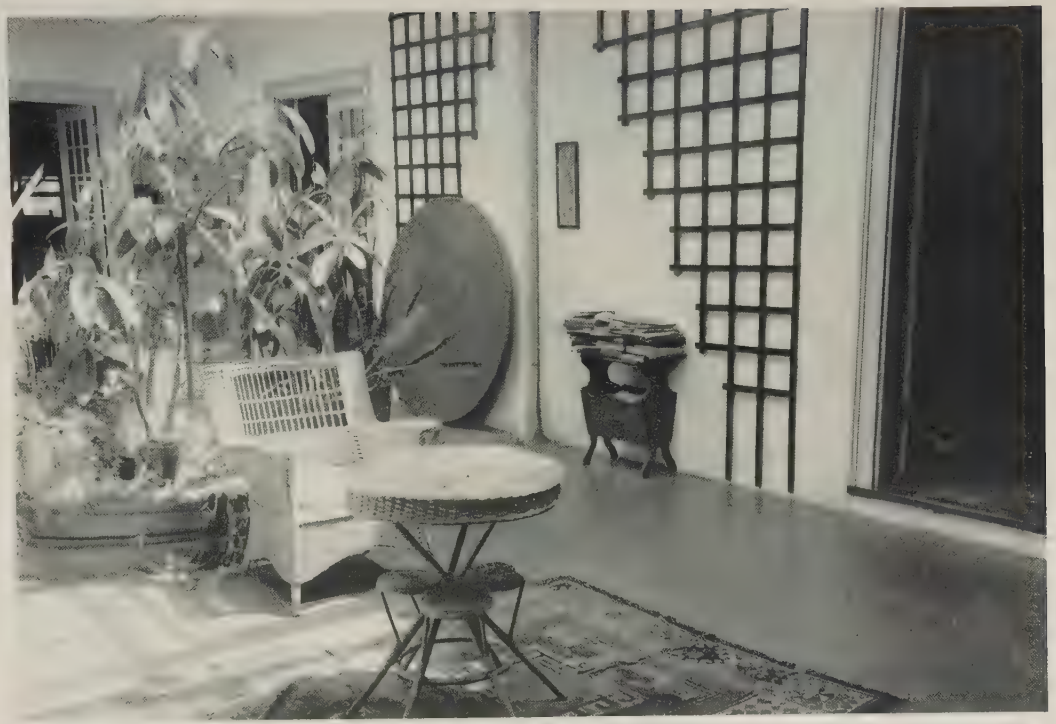


Poria fimbriatella (Pk.) Sacc. on *Quercus Kelloggii*, Placerville, California



Poria incrassata Murr. on planks of *Pinus palustris*, from the foundations of the old income-tax building, Washington, D.C.

A stucco house in Oklahoma which is badly damaged by *Poria incrassata*.
The foundations are inadequately provided with ventilators



Patio of house shown in Plate VIII. Moisture from plant culture, with that arising in stucco walls from foundations beneath, is sufficient for the rapid growth of *Poria incrassata*

FIG. 1. Infested hardwood floors of room adjacent to the patio of the house shown in Plates VIII and IX. The floors are greatly weakened and the wood badly decayed by *Poria incrassata*, especially at the point of contact of the stucco walls of the patio, the sills, and the joists beneath

FIG. 2. Badly decayed sill and joists beneath the hardwood flooring shown above

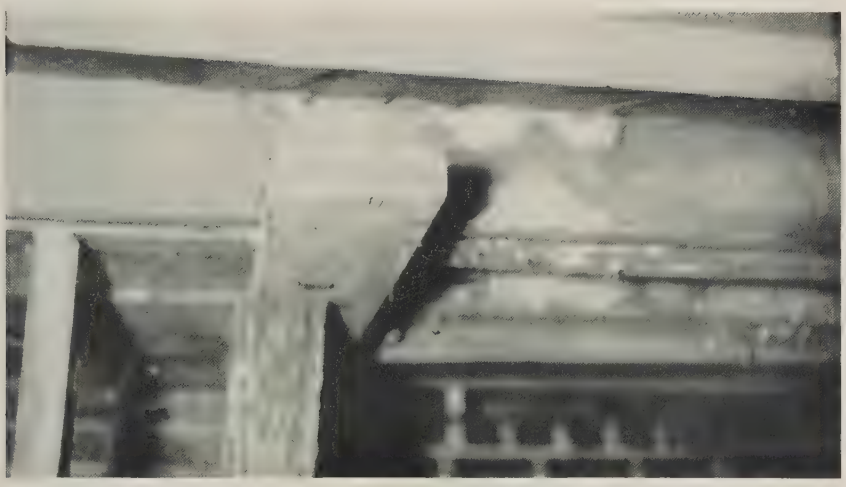
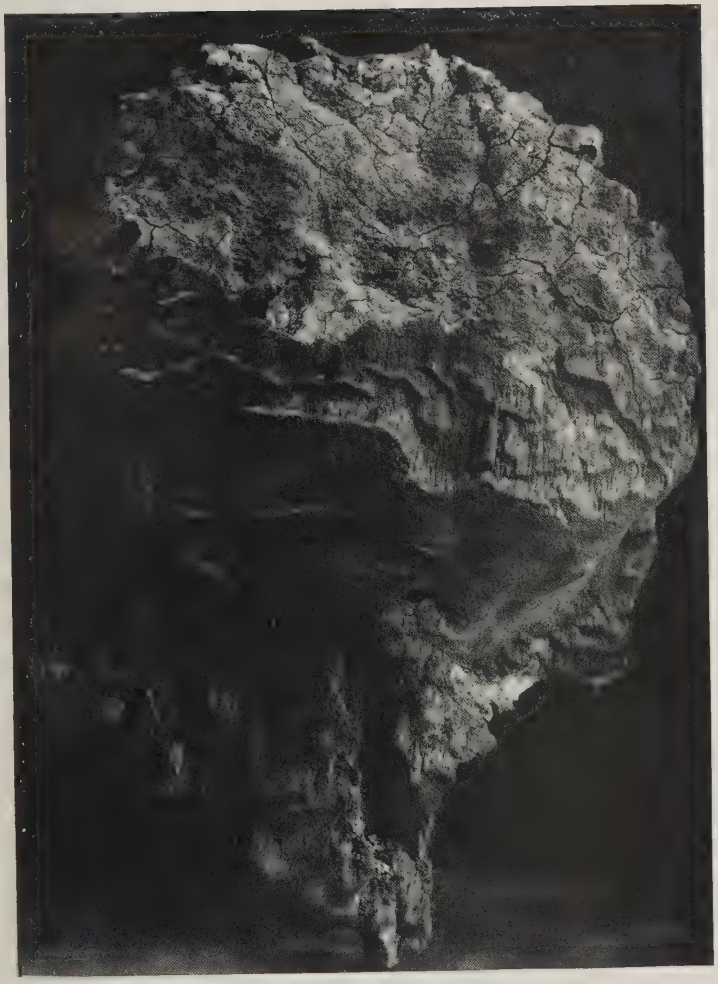


FIG. 1. Untreated timber used in "repairing" the damage caused by *Poria incrassata* and in supporting the infested joists of the stucco home. The wooden prop rests on the damp ground beneath the house

FIG. 2. Large supporting beam beneath the house, decayed by *Poria incrassata*. The timber used in the "repair" which props up the house is untreated. The rotten wood from parts of the old structure is left in the ground



Poria nigra Berk. on *Quercus velutina*, Ann Arbor, Michigan

FROST HEAVING OF FOREST PLANTING STOCK AT THE KELLOGG REFORESTATION TRACT, NEAR BATTLE CREEK, MICHIGAN

MERRILL E. DETERS

FROST heaving is a factor which in many regions limits the planting of forest tree stock in the fall. It occurs particularly in localities characterized by open winters and frequent periods of freezing and thawing weather. Other factors such as soil texture, aspect, drainage, and density of ground cover may markedly affect it.

In southern Michigan frost heaving may be so damaging that fall planting can be done only with much risk. Westveld and Van Camp [1] state that such planting is possible in Michigan north of a line from Bay City to Ludington because this region usually has a continuous winter snow cover which protects the trees against heaving. Where it can be practiced, fall planting offers the advantage of a greatly lengthened annual planting period and of many days of ideal planting weather.

The Department of Forestry of Michigan State College conducted fall planting at its Kellogg reforestation tract in the northeastern part of Kalamazoo County, near Battle Creek, Michigan, during the years 1931, 1936, and 1937. Results from experiments conducted there and from certain other tests make it possible to evaluate frost heaving in southern Michigan and also to suggest means whereby the risk of fall planting may be greatly lessened.

THE TRACT

The Kellogg tract is typical of reforestation sites in southern Michigan. It is made up of rough, eroded farm land which has been abandoned. The old fields have a cover of blue grass and the various weeds characteristic of old-field sites.

[1] Westveld, R. H., and Van Camp, J. L., *Forest Planting on Michigan Farms.* Michigan State College of Agriculture and Applied Science, Extension Bulletin 147, 1935.

FROST-HEAVING DAMAGE IN 1931–32

Data on mortality due to frost heaving in plantations made in the fall of 1931 were collected by R. H. Westveld and B. M. Kirk, formerly of the Forestry Department, Michigan State College. They are given in Table I. Each of the mortality percentage values is based on samples of one hundred or two hundred trees.

TABLE I

MORTALITY PERCENTAGES DUE TO FROST HEAVING DURING THE WINTER OF 1931–32

Species	Class of stock	Site preparation	Planting method	Mortality percentage
White pine	3–0	..	..	60
	2–1	..	..	23
	2–2	..	..	12
	3–0	..	Shovel (hole)	65
	3–0	..	Shovel (slit)	55
Red pine	..	Furrowed	..	43
	..	None	..	20
	..	Furrowed (mulched)	..	10
	..	None (mulched)	..	5
			Average mortality	32.6

During the winter of 1931–32 mortality averaged 32.6 per cent, with a maximum of 65 per cent and a minimum of 5 per cent. The data also show the various classes of stock affected. The mortality of stock of 3–0 class averaged 60 per cent as compared with 23 per cent for 2–1 stock and 12 per cent for 2–2 stock.

Site preparation and mulching also bring about significant differences. On furrowed areas 43 per cent of the trees were killed as compared with 20 per cent on unprepared ground. Mulching with straw gave best results, with losses of only 5 and 10 per cent on untreated and furrowed sites respectively.

FROST-HEAVING DAMAGE IN 1936–37

Data on damage during 1936–37 were collected from nineteen sample plots of one hundred trees each. They are given in Table II. Trees are here classified as "heaved," "partly heaved," and "not heaved." Heaved stock is that which was forced completely

TABLE II

FROST HEAVING OF FALL-PLANTED STOCK DURING THE WINTER OF 1936–37

Species	Age of stock	Site preparation	Aspect	Heaving percentage		
				Heaved	Partly heaved	Not heaved
	Unmulched seedling stock					
Austrian pine ..	2–0	Scalped	Level	16	48	36
Douglas fir	2–0	Furrowed	West	11	17	72
Douglas fir	2–0	Scalped	West	29	42	29
Jack pine	2–0	Scalped	Level	26	15	59
Jack pine	2–0	Furrowed	North	2	6	92
Red pine	2–0	Furrowed	Level	8	19	73
White pine	2–0	Furrowed	East	2	14	84
White spruce ...	2–0	Furrowed	West	31	34	35
White spruce ...	2–0	Furrowed	East	14	26	60
			Average	15	25	60
	Unmulched transplant stock					
Japanese red pine	3–1	Scalped	Level	0	63	37
Pitch pine	3–1	Scalped	Level	2	55	43
European larch.	2–1	Furrowed	West	7	35	58
Red spruce	2–1	Furrowed	West	6	40	54
Norway spruce .	2–2–1	Scalped	Level	0	21	79
			Average	3	43	54
			Average of all stock not mulched	11	31	58
	Mulched stock					
Austrian pine ..	2–0	Scalped	Level	4	15	81
Douglas fir	2–0	Furrowed	West	1	19	80
White spruce ...	2–0	Furrowed	East	6	20	74
Red spruce	2–1	Furrowed	West	2	15	83
Japanese red pine	3–1	Scalped	Level	0	14	86
			Average of mulched stock	2	17	81
			Average of all stock	8	28	64

out of the ground or had only small portions of the roots still in the soil. Heaved trees were no longer able to remain in a vertical position and probably could not have survived. Trees partly heaved

comprised those raised about one-quarter to one-half inch from the normal planted position. They remained erect and practically all became established. Trees classified as not heaved were in the normal planted position.

The data in Table II are grouped according to (1) unmulched seedling stock, (2) unmulched transplant stock, and (3) mulched stock. Sod from which the soil was shaken was used for mulching. Site preparation and aspect factors are included in the table, but there are insufficient data to bring out clearly their effects.

Although considerable damage occurred during the winter of 1936–37 it was much less than that during 1931–32. This may have been due either to a more favorable winter season in 1936–37 or to the different conditions under which the plantations were established.

Many of the trees completely heaved late in the winter were replanted during the spring of 1937, and most of them became established successfully. Soil was placed around the trees partly heaved, and little or no mortality resulted among them. It is very important, of course, to replant heaved trees before they have dried seriously.

FROST-HEAVING DAMAGE IN 1937–38

Plantings during the fall of 1937 were made on a valley site with slow surface drainage as well as on several well-drained sites. All stock was mulched and planted in furrows. Results are given in Table III.

TABLE III

FROST HEAVING OF FALL-PLANTED STOCK DURING THE WINTER OF 1937–38

Species	Age of stock	Aspect	Heaving percentage		
			Heaved	Partly heaved	Not heaved
White ash	1–0	Level (valley)	33	41	26
Norway spruce	3–0	Level (valley)	46	27	27
Green ash	1–0	West	7	60	33
Norway spruce	2–1	Level	0	14	86
Honey locust	1–0	Level	12	25	63
		Average	20	33	47

Most of the trees that heaved during the winter of 1937–38 were replanted in early spring, and many of them became established.

Heaving was particularly severe on the valley site. Despite mulching only 26 per cent of the white ash and only 27 per cent of the Norway spruce escaped damage. A high water table and loam soil probably account for the more severe heaving on the valley site. An added reason may be that green ash and honey locust are taproot species. These appear to be more easily heaved than species with branched-root systems.

DISCUSSION

A comparison of damage for the three years shows the highest mortality rate in 1931–32. The rates would have been even higher on the valley site in 1937–38 if no maintenance work had been done. Since, however, the data are not directly comparable it is sufficient to conclude that severe damage was suffered in fall plantings made in each of three years.

Transplant or large stock appears to have a definite advantage over seedling and small stock. Highest losses each year were from heaving of seedling stock. It was especially noted that under field conditions the smaller, weaker trees were the ones most commonly heaved.

Very little heaving occurred after the trees had completed one season's growth. Small 2–0 white spruce, however, heaved over one half as much in the second winter as in the first.

Furrowing gave better protection than did scalping. Table II shows this most clearly. Data in Table I indicate that far greater success was obtained without site preparation, either furrowing or scalping. Though the results may be favorable with respect to frost heaving, lack of site preparation may subject the young trees to an even more serious factor, plant competition.

The value of mulching is well illustrated in the data for all three years, especially those for 1936–37, when only two per cent of all mulched stock was seriously heaved. Of course, mulching required additional time. At the Kellogg tract it increased the cost of planting by 50 per cent.

Maintenance work in replanting heaved trees and tending those partly heaved added an average of 30 per cent to the original planting costs. On the basis of these tests fall planting with mulching and

maintenance the following spring increases planting costs by about 80 per cent.

The data are not sufficient to reveal clearly the relations between aspect and amount of frost heaving, but the level valley site showed by far the greatest amount, and the single plot with a north aspect was least affected.

PLANTING METHOD TO CONTROL HEAVING

In checking frost-heaving damage in the spring of 1937 it was noted that heaved trees were in exposed places or in small depressions where surface water might accumulate. Trees in the best condition were in well-drained, protected situations. For example, heaved trees had been planted on the north side of furrows plowed in an east–west direction. Trees planted on the south side next to the furrow wall were in excellent condition. Furrows were plowed to a depth of five to six inches and were ten inches wide. Those less than four inches deep did not give complete protection.

In the fall of 1937 there were planted in an east–west direction 2–0 seedlings of red pine, Austrian pine, and white pine, and 1–0 seedlings of honey locust. Trees were set by the hole method next to the south wall of the furrow, and a small mound of soil was built up around each tree. A piece of sod from which the soil had been shaken was placed on the north side of the tree in order to protect it from heaving on that side. Care was taken to compact very firmly the soil about the roots of each tree. The site was well drained and level to slightly rolling. The soil was a gravelly sandy loam.

From a sample of one hundred of each of the four species only three white pine and two honey locust trees were affected and they were only partly heaved. None of these were heaved sufficiently to cause measurable injury. It would seem, therefore, that this method of fall planting may prove useful in southern Michigan or other regions where frost heaving is likely to be serious.

SUMMARY

Frost-heaving damage to forest planting stock at the Kellogg reforestation tract is reported for the years 1931–32, 1936–37, and 1937–38. Under ordinary planting methods considerable losses occurred each year.

Heaving was more severe on a valley site with loam soil, slow

surface drainage, and high water table than on any other aspect on which tests were made.

Seedling or small, weak stock heaved more than transplant or large stock.

Mulching with straw or sod was markedly effective in reducing heaving damage.

Almost no injury was suffered by the fall plantings of 1937 that were made under the following conditions: (1) furrows plowed in an east–west direction; (2) furrows narrow, five to six inches deep; (3) trees planted close to the south wall of the furrow; (4) soil packed firmly around roots; (5) soil mounded slightly around base of trees; and (6) north side of tree mulched with sod from which soil had been shaken.

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SOME NOTES ON THE PREPARATION OF *CYATHUS STERCOREUS* AS A TEST ORGANISM FOR THE RAPID DETERMINATION OF DECAY RESISTANCE IN TREATED TIMBERS

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SINCE the publication of the works of Robert Hartig in Germany late in the nineteenth century the relationship of fungous hyphae to decaying wood has been recognized, and much study has been devoted to it both in the field and in the laboratory. Before Hartig's discovery of the relationship there had been numerous confusing theories which retarded the advancement of knowledge and control of wood decay.

There are open to the experimenter three general methods of approach by which the comparative preservative value of given chemicals may be determined. These are clearly described by Hunt and Garratt (4), and their applications are discussed at length by Schmitz and others (5–8, 10–11).

Several fungi are accepted by laboratory technicians as good test organisms. The Forest Products Laboratory at Madison, Wisconsin, recommends strongly a strain of test fungus No. 517, an unidentified isolate from a decayed mine timber (6). The Western Pine Association Research Laboratory in Portland, Oregon,[1] has based considerable work on tests with *Lenzites trabea* (Pers.) Fr., an active dry-rot fungus encountered in actual service. In some European laboratories *Merulius lacrymans* (Wulf.) Fr. is preferred because it is a troublesome building rot in Europe, whereas in this country *Poria incrassata* (B. & C.) Burt., *Coniophora cerebella* Pers., and others are selected for a variety of reasons.

All these fungi have their individual merits as test organisms;

[1] The wood decay studies are conducted under the direction of Dr. E. E. Hubert.

some are to be encountered under natural conditions; some show broad adaptability to wood species and environment; others display rapidity of growth or attack, while certain species are easily grown and propagated in pure culture in the laboratory. One group attacks lignin most strongly, whereas others seem to concentrate on cellulose. None meets all needs.

Several investigators prefer Petri dishes for culture chambers; another group, with equally good reason, employs Kollé flasks. Either utensil has peculiar advantages to commend it. Schmitz (8) and others (5, 7) discuss the advantages and the disadvantages at length.

Cyathus stercoreus

The writer brings forward another fungus, not the answer to the call for an all-purpose test organism but an addition to those already in common use. *Cyathus stercoreus* (Schw.) De Toni deserves further investigation as a fast-working laboratory tool. The genus Cyathus is not often studied by forest pathologists, and is seldom looked upon as more than a casual secondary organism on wood previously decayed by other fungi, but a species of it was tested in the forest pathology laboratory of Michigan State College and found to show considerable speed in growth and attack on wood and woody fibers.

The genus Cyathus belongs to the subclass Gasteromyceteae or stomach fungi. It is one of the four genera [2] in the family Nidulariaceae, and is the most common bird's-nest fungus found in the Lake States. Engler and Prantl (2) report it native to North America, the West Indies, Australia, and New Zealand.

In outward appearance the mature sporophores resemble tiny bell-shaped birds' nests, being smooth and plain rather than fluted or striate on the inner surfaces of the cups, and densely matted with short grayish brown hairs on the outside. The fruiting bodies, without their epiphragms (caps), measure about 7 to 10 mm. in height and about 3 mm. in diameter. On mature spore fruits six to twenty peridioles are exposed by rupture of the epiphragms. The peridiole is usually attached to the wall of the fruiting structure by a slender strand called a "funiculus."

To date there has been no success in the writer's effort to germi-

[2] Nidulariaceae is variously recognized to contain three or four genera; the genus Nidula is not held to be separate by some mycologists.

nate the spores of Cyathus in their peridioles. In nature, germination must come about through the decay of the hard peridiole wall or the breaking of it by animals, birds, or insects. Laboratory propagation is best attained by carefully loosening the newly matured peridioles from the spore fruit and dropping them on malt agar after rinsing them in sterile distilled water or dilute alcohol. Mycelial growth takes place rapidly from the broken funiculi. All of twenty peridioles tested grew abundantly in this way, and only two were contaminated by soil organisms (Actinomycetes). It appears that the Actinomycetes which are ordinarily associated with Cyathus in nature affect the fungus by causing the mycelium to grow flat along the agar. Very seldom does the fungus overcome the bacteria in vegetative competition.

The close natural association of Cyathus with one or many soil bacteria has gained for it a reputation as a slow-acting decay organism. Antibiosis, or the mutual inhibiting effect of fungus and bacteria, results in a retarded attack on wood by Cyathus, which is readily demonstrated in the laboratory. Freed of bacteria, *C. stercoreus* grows with rapidity, with luxuriant mycelium. It hardly resembles the slow-growing contaminated culture.

The normally saprophytic fungus is usually found in and on the soil, on manure or decayed organic matter, but Coker and Couch (1) mention a report of its fruiting on live sugar maple (*Acer saccharum* Marsh.); very probably it was growing without contamination, a condition rather rare in nature. Inoculations have been made by the writer on a living tree, but sufficient time has not yet elapsed for convincing results to appear.

In pure agar culture the mycelial mat grows faster at temperatures of 21° to 27° C. than any other wood-rot fungus tested on this medium. Few molds can equal its rate of hyphal extension; the main exceptions are various species of the Mucorales, on malt-agar plates. Malt agar is quickly bleached white by the growth of Cyathus, as it is by the Madison No. 517 fungus. Twisted mycelial sheets may form in the agar, and large drops of water usually occur in the mycelium.

The newly grown mycelium, which is fluffy-white, suggests tufts of down, but it assumes a rufous tinge after several days, and thereafter may darken until it becomes brown. Aërial mycelium is profusely septate and is marked by large clamp connections. While

the mat forms, tawny mycelial strands proliferate radially from the inoculum and quickly carry the fungus over the tops of experimental wood blocks unless the surfaces are highly toxic.

Technique Employed

Most of the work has been done on malt agar consisting of 1.0 to 2.5 per cent Trommer's liquid malt,[3] and 1.0 to 2.5 per cent bacto-agar. Sterilization of the medium results in less breakdown in the higher concentrations of agar. Since *C. stercoreus* must be grown in pure culture in order not to suffer loss of its wood-attacking capacity, the necessity for careful sterilization of the medium is seen.

If partial breakdown of agar does occur during sterilization, it will not impair the value of the medium, but either the precipitate should be settled or the clear agar decanted; otherwise the precipitate will interfere with early detection of contaminants. For fastest results in testing it is recommended that the agar plate be inoculated in several places with pure *C. stercoreus*, so that a continuous mat may be formed by the rapid coalescence of separate colonies. The agar should be watched carefully for evidence of contamination until it has been completely covered by mycelium (in from three days to a week).

There was little success in "operating" on cultures to remove Actinomycetes, thermophilic bacteria, or molds. Red-hot needles, spatulas, loops, etc. usually spattered spores or living cells; alcohol in any concentration served only as a temporary inhibitant. Some chemicals, such as copper compounds, were successful in killing contaminants, but they rendered sterile the portion of the agar plate which they touched. Hyphal-tip transfer to a new plate proved most satisfactory. As soon as the mycelial mat covered the agar completely, sterilized wood test strips were laid flat upon the fungus and allowed to remain for the duration of the test.

The sterilization technique of Schmitz, von Schrenk, and Kammerer (9, p. 68) has been followed with excellent results. Moisture in the wood, absorbed in boiling, hastened attack (and prevented the early drying out of the cultures). The intermittent dipping should be done carefully in boiling water, so that the moisture content of the test samples may not become unreasonably high.

When oven sterilization of wood was employed, it was found that

[3] Trommer's Diastasic Malt. The Trommer Company, Fremont, Ohio.

excessive dryness of the wood retarded the initial attack by fungi, a consideration of no small importance in rapid determination of decay resistance.

The speed with which certain fungi begin to attack an array of woods (and, later, the speed with which they spread over them) may be an important datum related to the durability of the woods. By the use of *C. stercoreus* it was found possible in one week's time to arrange a group of twenty-two native American woods in an order that corresponded almost exactly with relative durability ratings published by the Forest Products Laboratory after lengthy research. It is problematical whether or not the work could be duplicated with the woods of all commercial tree species, but it would appear that initial spread of mycelium is worthy of more study.

Several observations follow on this rapid forecast of decay resistance by noting the appearance of aërial mycelium of Cyathus. Aërial mycelia spread rapidly over the sapwood of the species tested in a period of two to four days, provided toxic extractives from certain heartwoods were excluded. In one instance the heart-sap boundary in a durable species (*Catalpa speciosa* Warder) was a razor-sharp line, with heavy mycelial mat on the softwood and absolutely bare heartwood; on some other species there was a heavy mycelium on the sapwood and light on the heartwood. It appears fairly certain that the profuseness of aërial mycelium in Cyathus is almost directly proportional to the availability of food in the substratum immediately below. So far no quantitative data have been collected to substantiate the apparent fact, but the close correlation between mycelial growth observed *in less than a week* on given woods and the published durability list of those woods leads to the belief that fast approximations suitable for industry could be made with about as much accuracy as that of meter indicators of lumber moisture content (3). No laboratory decay-resistance tests can give more than approximations of expected service life, regardless of the accuracy of measurement.

It is recommended that two things be done with cultures in either test tubes or Kollé flasks when it is desired to allow fungi to work on wood until they run their courses to an appreciable loss in oven-dry weight: (1) that the mouths of such test tubes and Kollé flasks be stoppered with the standard cotton plugs, with coverings of Parafilm [4] or similar material put over them to retard drying out; and (2) that

[4] Made by Menasha Products Company, Menasha, Wisconsin.

identifying labels be applied to the bottoms of the containers rather than near their mouths, so that there will be no danger of the mycelium's creeping out of the glassware through the cotton stoppers and obliterating the labels under the sealing material. Such loss was experienced with several test fungi.

Evidently Parafilm is not gas-tight, for not only do aërobic fungi appear to grow well when sealed with it, but also strong odors such as those of some Actinomycetes may be readily detected through it. Nevertheless, it retards the loss of moisture to the extent that test-tube cultures may be kept in excellent condition for at least a year without noticeable shrinking of the agar. Matched unsealed cultures would long before have shriveled to a stony mass. Of course, a high-humidity chamber would answer the same purpose.

It is recommended that at the end of the test period the test blocks be removed unsterilized from the culture chambers, so that careful inspection may be made of them, unhampered by melted agar or heat-browned hyphae. This recommendation should especially be observed with such fungi as may discolor the wood only slightly under natural action of the fungi. The mass of external hyphae may be carefully scraped off and the condition of the wood surface noted before putting the specimens into the oven to determine their final oven-dry weights.

The determination of timber durability is more than a laboratory matter. The present prosperity and the future existence of our lumber industry depend to no small extent upon a more exact knowledge of wood properties. Durability is a factor of greatest importance in many applications of timber.

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